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VOL. XXVIII APRIL, 1930 No. 4

The Society is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

THE NEXT TWENTY-FIVE YEARS[1]

BY R. Y. STUART
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THE groundwork for forestry has been laid. We cannot claim more.

In retrospect we see the national forest system well entrenched with a steady advance in the protection, administration, and development of the national forests and yet markedly lacking in capital investments and in their influence upon the general forest situation. We see state forest organizations functioning in practically all forested states, grappling with the fundamental needs of the state forest requirements. We see private owners of forest lands increasingly conscious of the exhaustibility of the forest resources but for the most part indifferent or claiming impotence, without public assistance, in applying necessary safeguards against destructive forest practices. We see the acreage of non-productive forest lands increasing and augmented by an expanding acreage of marginal and submarginal agricultural lands with forest potentialities. We see the general public slowly responsive to the urge for more and better forest practice.

Forest administration and protection will undergo a severe test in the next twenty-five years. So will professional foresters. Notwithstanding the marked advance steps taken in national and state forest organization, in organized forest protection and comprehensive plans for forest research, and in the coöperative relationships between public and private agencies for the promotion of forestry, nothing short of a decided trend toward balancing the forest budget of the nation will satisfy the public need and expectation. It is inconceivable that as a nation we progressively accumulate extensive areas of non-productive land. It is also inconceivable that we shall continue ruining land productivity by abusive forest practices over extensive areas.

As we enter the second cycle of organized public forestry, foresters face the test not only of efficient administration and protection of public properties but also of the success with which they cope with the curtailment of land spoliation through abusive forest practices.

[1] Written following the celebration on February 1, 1930, of the twenty-fifth anniversary of the creation of the Forest Service. —ED.

NATION-WIDE SOLUTION OF FOREST PRODUCTION PROBLEMS OF THE UNITED STATES

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Résumé of the Forest Situation

WE ARE in the apparent position of possessing abundant productive forest resources. There is a basic forest resource of 470 million acres of forest land, of which about 120 million acres bear virgin forest. Forest growth is estimated by the U. S. Forest Service to amount to approximately 6 billion cubic feet annually, while use amounts to about 18 billion, and the total drain to about 25 billion cubic feet.

Any program of forestry should be based upon reasonable estimates of future forest requirements. This is, at present, a very controversial subject. Some authorities hold that future use of forest products will decline. Due consideration to the accelerating pace of modern industry furnishes convincing proof that before our present industrial stride has slackened, near exhaustion of all natural resources, including the forest, will be brought about. Indeed, since the forest is one of the few renewable resources, and many other resources now relied upon by industry will be seriously diminished within a relatively short period, it seems obvious that we shall rely in future to an increasing extent on the forest. The fact that the United States, where modern industry has advanced most rapidly, consumes more than half of the forest products of the world, other than fuel, despite having only about one-sixteenth of the world's population, is good evidence of the effect of modern industry in this respect. Some uses, such as lumber, may decline, while others, such as pulp, paper, and textiles, constantly increase. There is, in fact, no doubt that requirements for forest products will, in the future, exceed the results of any program that can be executed, even if we use the utmost care in proceeding along lines tested in other fields so that they will be acceptable to a substantial majority of our people.

Despite the obvious need for continuous production, our position has been rendered insecure by a discouraging blending of economic fatalism, ignorance, and indifference on the part of forest owners, unrelieved by sufficiently vigorous action by statesmen and foresters. Professional foresters, too often lacking a deep understanding of the national problem and a firm will toward an adequate solution thereof, are open to censure for failing to furnish constructive leadership to forest owners and the public. Extensive discussions of these problems have occurred in government bulletins, the Journal of Forestry, and the press in general, leading to clarification of the issue. Detailed consideration beyond the bounds of this article may be found in literature cited below (1, 2, 3, 4, 5, 6). The evidence contained in

these discussions is ample to prove that unless radical improvement is made in our methods of handling forests, exhaustion impends within a generation.

Many students of this urgent problem believe its solution can be accomplished only by public ownership and management. We must not forget that this is only one of innumerable modern problems pressing for solution by government. So great has the pressure become that the entire structure of government is under severe stress. Easing the burdens of government means the utmost utilization of private initiative and activity. It is, therefore, necessary to consider the economics of private forest management before intelligent allocation of responsibility can be made between public and private agencies.

Economic Position of Private Forestry

Since good forest management is in essence only good business management, it is applicable at all stages of economic development, and does not await high stumpage prices and other evidences of forest exhaustion.

In promoting effective forest management we are merely promoting the conservation of capital values as against waste of those values. In the properly organized, continuous-yield forest, the writer estimates that capital values will be distributed somewhat as follows: Land 20 per cent, trees 60 per cent, improvements 20 per cent. Values in the virgin forest developed to the point where lumbering operations can begin show a similar distribution, except that the land is usually less regarded. The abuse of American forests has arisen through recovery of only the merchantable timber, treated like a mineral resource. In this way, the land and improvement values, and much of the tree values, are thrown away by unwise use of the tree values.

Successful forest management demands application of the same investment principles that are applied in other successful businesses, viz., to perpetuate the values which will earn as part of the continued investment, and recover values which will no longer earn satisfactorily. The land and improvement values are mostly incapable of recovery except through continued use as part of the forest property. The chief knack of forest management consists in analysis of, and proper order of the recovery of, the tree investment. Methods of analysis are now available which amply show what trees and stands will yield profits only by holding for future cutting (6). It is now evident that even in the magnificent forests of the Pacific Coast, not over 25 per cent of the stands are capable of yielding profits by immediate cutting. The remainder may be expected to yield the same splendid profits to the able forest owner who will hold for future cut, that the so-called unearned increment has yielded owners in the past 25 years. Why should any other conclusion be reached?

The violation of these correct principles of cutting is at once the chief source of the ills of the lumber industry, and the cause of the wanton destruction without profit of millions of trees annually. The proper and universal application of the correct principles will reduce market over-supply, conserve present trees and stands sufficient for many years' cut, and give ample time for new trees—the offspring of those saved—to take their place

in the forest ranks. The trees not now valuable for cutting are thus the key to the conservation and increase of forest values and productivity. These trees and stands which have been, and are, so little regarded by many owners because of lacking present value, constitute in fact the greatest neglected investment opportunity in America.

Forest owners should proceed without delay to organize forest properties, wherever they exist, for continuous production, in a manner to absorb their due proportion of the huge capital now seeking investment. It is well known that billions of American capital now lie invested in stocks and other investment forms on the basis of less than 3 per cent interest yield (7). The diversion of a few billions of monied capital from the security markets to actual forest investment would restore sanity to " Wall Street " and again send the economic life blood flowing through the forest communities. The stabilizing effect on permanent prosperity would be incalculable. Recognition of his opportunities by the private owner constitutes an outstanding item in our program.

The Program

On the economic foundation thus briefly sketched must be erected the forest program capable of successful execution. Such a program should eliminate prejudice for or against public or private enterprise as such. It should provide for such blending of public and private action as will be at once politically and economically feasible, and of such scope as to surely provide the desired results. Public enterprise is necessary because much of our forest area has been so badly handled as to lack the trees necessary to make it productive at a sufficiently early date for private enterprise to succeed. Public action is also necessary to a certain extent, to create favorable conditions under which private enterprise may function.

The chief object of the program is to stabilize forest ownership in the hands of public and private owners who will consider the continuous care and productivity of their forests as a permanent responsibility. The program to secure these results necessarily consists of several more or less coördinate items. Of the measures necessary, the first three are considered to be of outstanding importance.

Federal Activity

The federal government should spend 50 million dollars a year for a period of at least ten years for acquisition of additional forest land, together with replanting and construction of ample improvements to insure full forest productivity on the acquired area and the existing national forests. The development program should also give due weight to the subsidiary benefits of forests, including flood control, game protection, and recreation.

Our list of measures is headed by this item, because no other measure can secure such immediate results. Moreover, it is politically and economically susceptible of immediate execution. The federal government has ample financial resources, and is already aware both in Congress and the Executive Departments, of the urgent need. The Forest Service, with its trained personnel and executive competence, is fully capable of

executing this large program. The undue moderation of forest proponents should be permanently abandoned, and when requesting appropriations they should speak in convincing terms used by other comparable interests. To those who have considered this subject, insured forest productivity certainly seems to equal or exceed in importance such national enterprises as the Boulder dam, Mississippi flood control, and other enterprises each of which concerns actually only a relatively small part of the nation. Continuous forest productivity concerns every citizen.

EDUCATION

This should come first, were it not for the slowness of the process in a field where time presses. Education must be relied upon to consolidate the gains which our first measure can accomplish, and build a firm foundation for state and private forestry. It is best considered under three heads.

Within the Profession of Forestry. If the profession of forestry cannot lead in a wise national program, who can? Unfortunately, in too many individual cases the professional standards, presumably inculcated in the forest schools, fail to become firmly knit into individual character. When such individuals permit a venal surrender of their principles in working for private interests, the results are deplorable, and the public money used for their education was wasted. The entire profession should reexamine its economic and cultural foundations. Those individuals who cannot then discover sufficient justification for professional conduct in the public interest should cease to label themselves foresters. When members of the profession can show pride and loyalty to their calling, together with qualities of leadership in this field of national service, education of the private owner and the public can be efficiently carried on.

Education of Forest Owners. This involves a campaign of education among all forest owners through their own associations, and federal and state agencies, to secure recognition of proper cutting practice, with a view to no longer burdening the market with lumber from trees cut and manufactured at a loss, and of equal importance, the recognition of the high investment values of trees and stands so saved for future cutting. Only in recent years have data become available to make such a campaign successful in all parts of the country. Particularly in the Pacific Northwest is the time ripe for such an effort. Aside from the creation of centralized management, which is a very difficult project politically, this must be the main reliance for stabilizing conditions there.

General Public Education. Publicity concerning aims and activities of the federal forest program will be an important source of public information. School curricula should give due place to consideration of the forest resources in such studies as geography, economics, etc., with the aim of cultivating pride in conserving forest products for the generations to come, and disdain for the ignorance and selfishness that have ruthlessly destroyed them. Children's influence is mighty, and immediate. Public education must also be closely associated with all development of forestry by state and local governments.

FINANCING FOREST INDUSTRY

A financial institution of the character of the Federal Farm Loan Board should be created which will use collateral consisting of first mortgages on forest properties, to secure large loans in the cheapest money market, with the object of placing necessary capital in the hands of forest industry at interest rates enjoyed by industries capitalized in large units, and more recently by farmers, due to federal aid. No subsidy to forest industry is here contemplated. Federal aid in organizing an institution of proper size, with an initial financial endowment to start doing business, is, however, necessary. Greeley showed that forest loans averaged about 7 per cent interest. This is as much as 2 per cent more than other large industries pay under normal conditions (7). This need has been little discussed, but is of the first importance. It is obvious that no industry can successfully pay an interest rate larger than its normal earning rate. The removal of this handicap would lift an unnecessary burden comparable to the whole cost of taxes if full use be made of the contemplated loan agency.

Of the three foregoing items, the most difficult is education of forest owners to their real opportunities. Efforts of the past have been somewhat discouraging, but at no time in the past have business men of all types so eagerly sought economic information, or considered the status of their industries as a whole so carefully. If the profession can equip itself to give the information in the proper form, conditions are favorable to its being received and acted upon. In the meantime, pending the process of general education, a great deal of firmness will have to be exercised by informed authorities.

RESEARCH

Although it is probably true that more knowledge is already available than the average forest owner will have put into effect in the next half century, research can furnish information and fresh stimulus which the more advanced owners are ready for, and which, in many cases, can be put into effect on public forests immediately. Moreover, many forest facts can only be secured after many years of continued observations.

TAXATION

No program would be considered complete if this subject were omitted. After many years' search for evidence of overtaxation of forest industry as compared with other industry, none has come to the attention of the writer. Recently an examination of report of the Federal Income Tax Division for 1926 revealed that for corporate industries state and local taxes on the lumber industry constitute a less percentage of total income than in many other industries, *e. g.*, mines and quarrying. As these reporting corporations constitute the bulk of each industry, the percentages may be considered representative. There is, however, need of redistribution of taxes within the industry, with a view to collecting the bulk of the taxes at the time income is received, *viz.*, at the time timber is cut and manufactured. When the industry asks frankly for this redistribution, and the public understands that it is not trying to shift its burden to others, necessary tax changes should be easily secured.

STATE ACTIVITIES

The states, generally speaking, have not built up effective and stable forest departments capable of effectively admin-

istering forest affairs, and in particular furnishing a full measure of fire protection such as the city fire department provides. Many forest land owning states have yet to provide good management on the forest lands already owned. Unlike the federal government, whose agencies are fully capable of handling an immediate large program, state forest development can proceed only as fast as public opinion becomes sufficiently enlightened to keep state forestry from functioning largely in the interests of local politicians. Its great importance consists not so much in the immediate volume of forest production realizable, for its development must necessarily be slow, as in creating a growing public consciousness of the necessity of forest perpetuation.

COMPULSORY FORESTRY

Federal and state authorities have been wise in the very cautious use of compulsory measures. If possible, they should be confined to such steps as compulsory fire patrol, assessment of the share of the cost of fire suppression on the landowner, and other measures to prevent careless or indifferent individuals injuring the general welfare. In general avoidance of the advocacy of compulsory forestry throughout this program, the writer has adhered to the American tradition of free initiative and voluntary coöperation.

FEAR OF PUBLIC OPINION

Much of the forest destruction has been, and still is, caused by individuals trying to monopolize the lion's share of the forest wealth of their communities, and cash in for a quick profit. History cannot fail to accord an ignoble place to these ruthless profit makers and destroyers of the nation's wealth. Some of these will continue their depredations no matter what practices others adopt. Let us, in future, recognize such individuals and concerns, and hold them up to public scorn. Where large areas are annually devastated, local and national publicity should be given the persons responsible for the resource destruction. Why wait the verdict of history when the immediate branding of these operators as social enemies can help save our forest resources?

To those who may think this program complicated, owing to its many lines of attack, and to those who have a simple remedy to perform the cure, we answer that civilization and industry, like life itself, are complicated, and only through coördination of many activities and agencies can the great problem of forest continuity be solved for our country.

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A FOREST POLICY FOR THE UNITED STATES

By E. P. MEINECKE

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The Argument

BOTH the supply of timber and the expected growth fall far short of the needs of the Nation. Devastation of productive forest land through forest fires and destructive logging, promoted by waste in the woods, in manufacture, and in use, is progressing at an alarming rate.

The main difficulty in dealing with the decline of American forests lies in the chaotic condition of the lumber industry which controls four-fifths of the forest lands of the country. This condition is due partly to oppressive state taxation but mainly to internal disorders of an economic nature arising from land speculation and ill-advised financing in the past. The resultant over-production of lumber is particularly heavy in the Douglas fir industry, which in turn is largely responsible for nation-wide overproduction and consequent depression.

It is admitted that private forestry, entailing heavy expenditures without income beyond the life of the present generation, is possible only if the financial burden now depressing the industry is lightened and if special inducements are offered.

Great diversity exists between regions and localities as to present and prospective condition and productiveness, logical and probable use, taxation, accessibility, and relation to market, which make an attempt to treat all lands uniformly both unjust and impossible. Each case must be dealt with on its own merits. Private forestry is economically possible only on productive forest lands.

The appeal to the private timber holders for voluntary action has so far met with indifferent success, and there is little promise for betterment in the future from that source. The problem of a continual and assured wood supply is plainly a matter of national concern and cannot be solved by the lumber industry or by individual states, since it involves a responsibility to coming generations of all the states that rests squarely upon the national government. The interest of the United States in the productiveness of its forests is sufficiently great to warrant the offer of financial relief to such owners as take adequate steps to protect and perpetuate their forests, through reduction in federal income tax, preferential treatment in timber sales, and loans at a fair interest rate. Further relief must be expected from the much needed reform of state forest taxation. It is recognized that private owners are entitled, in return for state taxes paid, to a measure of protection from fire and that it lies in the interest of the individual states to afford such protection and to foster by all means the permanence of the lumber industry and of the secondary civic and industrial developments dependent upon it.

The protection of the remaining forests, their conversion into young produc-

tive forests, and ultimately the care of these must be effected, in the main, through the relatively small number of private owners holding the largest percentage of forest lands in the United States.

Protection from fire, sanitation of the industry, and rational classification of forest lands constitute the first and most urgently needed steps to be taken. The field is then free for an attack on the second great group of problems, that of the silvicultural treatment of producing forest lands to insure a maximum and continued yield.

The silvicultural activities of the U. S. Forest Service, under present limitations, consist of the single act of forest rejuvenation through regulated cutting on timber sales. Owing to conditions inherent in the system of timber sales on a stumpage basis, this rejuvenation is far from adequate from a silvicultural standpoint. Furthermore, the Forest Service is not empowered to care for the young growing forest and to increase its productivity for a second cut. The result is the creation of a wild, uneven, and not fully productive stand in which growth is left to chance.

The Forest Service is not in a position to assume its natural leadership through the example of accomplishments on its own lands beyond the first step of partial rejuvenation. It is powerless to exert a moderating influence on the lumber market and therewith on the cut.

The government owns a relatively small percentage of forest acreage and is overloaded with marginal and submarginal forest lands. The general tendency is to induce the government to increase these poor and unpromising holdings through acquisition of cut-over lands by purchase or exchange.

If the government is to fulfill its normal function to provide for maximum production on its own holdings irrespective of what is done on private lands it must own and manage a much larger acreage of high potential productiveness than it now possesses. The ownership of marginal and submarginal lands cannot strengthen it in its logical rôle as a regulating influence in American forestry.

The Program

The program endorses the principle that vigorous action should be taken first on the problems that are most urgent and most promising of results.

It is proposed to create a nonpartisan U. S. Council of Natural Resources, with subordinate boards, one of which is the National Board of Forestry.

U. S. COUNCIL OF NATURAL RESOURCES

The U. S. Council of Natural Resources (representatives of the Departments of Agriculture, Interior, Commerce, Navy, three leading specialists in national economics, three leading engineers as specialists in oil, water, and forestry) considers the national and international aspects of conservation and development of the great natural resources (oil, forests, and flood control as affecting natural resources) and decides on matters of policy. It has the right of initiative through its executive boards and the right of approval or veto in all matters of national or international importance. It is the court of last appeal.

NATIONAL BOARD OF FORESTRY

The National Board of Forestry, as one of the executive boards of the U. S.

Council of Natural Resources, is directly responsible for the formulation of policies and plans for the protection and perpetuation of the forests in the United States. Its members are chosen from the Forest Service, state foresters, deans of schools of forestry, U. S. Offices of Forest Pathology and Forest Entomology, and the lumber industry, and it has power to deal and negotiate directly with the individual states and with private owners. It will devise and carry into practice plans and methods for forest protection from fire, diseases, and insects, for prevention of destructive logging, for placing the forests as a whole on the basis of the sustained yield principle, for the perpetuation and improvement of the most promising forest lands. Its first duties consist in setting up definite rules embodying the minimum of protection from fire, insects, diseases, and destructive logging on the basis of regional and local conditions and to recommend to Congress and to the states concerned such legislation as will be necessary to reach this end. Concurrently it will cause an expert survey to be made for the classification of privately owned forests and forest lands with regard to their prospective use and value (wood products, protection, water and flood control, scenery and recreation, grazing) to serve as a basis for the type and degree of protection needed.

A survey of the wood-producing holdings is indispensable for the segregation and grading of forest lands on the basis of productiveness, composition of forest cover, accessibility and economic conditions, both present and prospective, size and presumable life of operation. This classification will constitute the foundation for a system of minimum silvicultural requirements. A rough grouping on the basis of productiveness is proposed in three classes, hereinafter referred to as Class A, Class B, and Class C. Class A comprises forest lands of the better site qualities which promise reasonable response to such silvicultural measures as are economically possible in the United States. Class B comprises marginal lands of poorer sites and devastated lands of the Class A type with an uncertain future. Class C takes in submarginal lands, not promising forest production without excessive expense.

FINANCIAL RELIEF

The National Board of Forestry will seek, through Congressional action, to obtain a proportional reduction or exemption in federal income taxes for those private owners who have, in the unanimous opinion of the National Board of Forestry, fully complied with the minimum requirements presented by the latter. It will further formulate guiding principles for a uniform reform of forest taxation in the states concerned and will endeavor to bring about appropriate state legislation.

Although weighty objections can be raised, on grounds of political economy, to a system of government loans, the urgency of the situation may justify such loans, on a long-term basis and at a reasonable interest, to be made through the medium of Regional Forest Associations or Boards, officially recognized by the National Board of Forestry and responsible for the bona fides of their members. The loans are restricted to members practicing at least forest protection up to the standard set by the National Board of Forestry and are increased on a sliding scale in accordance with ac-

ceptance and execution of the silvicultural requirements established by the National Board of Forestry.

The formation of representative Regional Forest Associations organized on principles determined by the National Board of Forestry should be encouraged. State foresters and district foresters of the region concerned should serve in an advisory capacity.

FOREST PROTECTION

Instead of leaving the initiative with the lumber industry the National Board of Forestry will present to the individual owners, directly or through the intermediary of the states concerned, a definite plan for the minimum of protection needed on their lands, formulated with due regard to regional and local conditions. This plan should carry a time limit of two years for acceptance and an additional year to carry the plan into effect.

The program provides for a tripartite agreement between the national government, the individual state, and the private owner, allotting the cost of fire protection on the basis of equal contributions from each party for those lands which, in the judgment of the National Board of Forestry and the state concerned belong to Class A. For Class B lands the owner contributes only one-sixth of the cost, and for Class C lands the cost is borne, share and share alike, by the federal government and by the state concerned. The program further provides for compulsory measures in case of non-compliance by the private owner within the time limit set, based preferably upon agreement between the government and the state or, if such agreement fails to be reached within three years, enforced by the federal government alone.

The minimum requirements for protection from fire (to be followed later with protection from diseases and insects) are served individually on all private owners, preferably through the Regional Forest Associations or Boards. Exception is made for those owners whose holdings are too small and unimportant to warrant their inclusion in the system. Compliance within the time limit entitles the owner to an appropriate reduction in federal income tax and, preferably, also in state taxes. It further entitles him to preferential treatment in government timber sales unless incompatible with the interests of the government. Non-compliance or failure to carry his contractual obligations into effect entails forfeiture of privileges offered and subjects the owner eventually to compulsory measures. The formation of coöperative groups, with or without state participation, for the purpose of fire protection and coöperative agreements between owners and the Forest Service should be encouraged.

FOREST IMPROVEMENT

A period of three years is allotted for the classification of forest lands in private ownership and for the formulation of regional and local plans dealing with measures to maintain and perpetuate the productiveness of the forests. These will serve as a basis for individual plans embodying the minimum silvicultural requirements set up by the National Board of Forestry. Two additional years are needed for the elaboration of the individual plans so that the latter will be presented to the private owners, pref-

erably through the Regional Forest Associations or Boards, after a total of five years from the inception of the system. The minimum silvicultural requirements lay emphasis, first, on the restriction of destructive logging and, in the second place, on methods of cutting to insure natural reproduction. They are, in each case, determined and decided upon with full regard to the specific situation and outlook and are applicable only to those lands which, in the judgment of the National Board of Forestry, promise adequate returns (Class A lands). The minimum silvicultural requirements should be complied with on 50 per cent of Class A lands within ten years and on all Class A lands within twenty years. A definite time limit for acceptance is set by the Board.

Acceptance of the silvicultural requirements within the time limit set entitles the owner to a further reduction in federal income tax, to further preferential treatment in government timber sales, and to granting of government loans. Failure to enter into a definite agreement within the time limit set or non-compliance entails forfeiture of these privileges and of any privileges granted in the future. Compulsory action is not at present contemplated in the case of silvicultural requirements. In ten years the effect of the program will have made itself felt, and the situation at that time, particularly with regard to destructive logging, will offer a better foundation for further and more stringent action.

The problem of silvicultural management of Class B (marginal) lands is postponed for ten years. Class C lands are excluded from present consideration.

SANITATION OF THE LUMBER INDUSTRY

The National Board of Forestry will make the strongest effort to relieve the depression in the lumber industry and to place it on a firm basis through sanitation of the economically unsound conditions in the Douglas fir region since no progress is possible until this situation has been remedied. It may be preferable to have this sanitation effected by the industry itself or through interstate compacts to which the federal government would be a party as has been proposed for the regulation of drilling for oil. The situation in the Douglas fir region as well as in others where similar conditions prevail must speedily be cleared up, even if it results in the breaking down of weaker and unsound concerns. The system of government loans to responsible owners, directly or preferably through the medium of recognized Regional Forest Associations or Boards, is perhaps the most promising means to bring about financial sanitation.

U. S. FOREST SERVICE

The national government has no interest in acquiring, by purchase or exchange, forest lands of poor quality or left in such condition through destruction that they can be brought back to productiveness only through expensive planting. In its acquisitions it should concentrate exclusively on high-grade forest lands except where it is advisable, for administrative purposes, to round out its holdings. The U. S. Forest Service as the representative of the government is entrusted, beyond all others, to provide for an adequate timber supply, directly from its own lands and indirectly through the example it sets to private

owners willing to practice forestry. It should be strengthened to a point where it can exert a regulating influence on production and should be freed from the necessity of adjusting its silvicultural plans to the chances of timber sales. Greater freedom in fixing stumpage rates is needed for treating with operators willing to enter into an agreement for forest protection and silvicultural management of their lands. It is proposed to enlarge the program of forest land acquisition to a point where ultimately 30 per cent of the producing forests are in the hands of the government. It is further proposed to enable the Forest Service to conduct logging operations on its own lands when and where good silviculture and good management make it desirable and where timber sales do not achieve the same object, with the proviso that the logs harvested shall be sold even at a loss if silvicultural ends are served thereby.

The Forest Service should be empowered, through Congressional action, to carry its silvicultural activities beyond the first step in forest improvement through the means of timber sales and to take such measures on its cut-over lands as will insure an approach to the cultivated highly productive forest.

Federal legislation should be sought to enable the United States Government to accept for protection and management, upon recommendation by the National Board of Forestry, within five years from the passage of the law, privately owned forest lands when offered, with the option of purchase within twenty years. The administration of said lands shall be in the hands of the U. S. Forest Service.

STATE, COUNTY, AND MUNICIPAL FORESTS

The acquisition of forest lands by states, counties, and municipalities should be encouraged. Every effort should be made by the state to place forest lands reverting to it for taxes without delay under adequate management.

A PROGRAM FOR STABILIZING PRIVATE FORESTRY IN THE UNITED STATES

By W. N. SPARHAWK

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PERMANENT private ownership and utilization of forest land will not be possible without a continuing demand for forest products. Unless we are going to need timber in a large volume in the future, we may as well plan to bring practically all forest land into public ownership, either by purchase or by default, and to utilize it only for recreation, water storage, game production, and wilderness. Private owners cannot afford to own it, unless it is relieved of all obligation to contribute its share toward the public revenues, nor will there be any reason for the public to attempt to raise crops of timber.

Without a fairly steady or even an increasing demand for forest products, there will be no profit in forestry. Without a fairly steady supply of forest products, the demand is sure to fall off. If they are unable for any considerable period to obtain their requirements of timber, industries using wood as a raw material will close down, their plants will be dismantled, and their capital diverted to other industries. Consumers of their products will turn to other materials, and forest crops maturing from then on will find a market only with difficulty, and at prices that will not repay the costs of production. Regardless of the fact that consumers may be able to get along without wood, the country will have lost one of its major industries—one which has contributed and should continue to contribute very largely to our material wealth and national well-being.

Although our potential national output of forest products is still greatly in excess of the demand, and likely to remain so for several years to come, the time is rapidly approaching when a sharp decline in production will be inevitable. Whether this decline will come in 20 years or in 40 years is immaterial. That it will come sooner or later if present trends continue is certain.

For continued production of timber the maintenance of an adequate stock of growing timber is absolutely essential. The volume of this growing stock will determine the quantity, and the character of the growing stock will determine the kinds and quality of timber that will be produced. The volume of the reserve stock of mature and overmature timber is significant only temporarily. The area of newly restocked young growth has little significance in considering the volume of timber production during the next 60 to 100 years. It is the trees that are now partly grown which must supply most of our needs for timber for many years after the bulk of the old reserve supply is exhausted.

The rapid depletion of the stock of growing timber, and its constant deterioration in quality, is the outstanding fact of the forest situation in the United States. This far outshadows in signifi-

cance the depletion of the virgin timber, or the non-use of the lands that have been deforested in the past. Regardless of the supply of old growth, and of the areas now reproducing or that may be reforested within the next 10 or 20 years, the present volume of growing timber cannot possibly support a sustained output equal to even half of our present cut. And even this inadequate stock is steadily diminishing. In the Northeast a large portion of the cut now comes from growing stands that ought not to be cut for several decades, in spite of the fact that cheap supplies of better material are available. In the southern pine region the second growth is being ruthlessly sacrificed, much of it at prices far below its real worth, although ample supplies of older and better timber can be had. Even in the Pacific Northwest, cutting of many of the thrifty stands of young growth is adding to the difficulty caused by overproduction from virgin stands.

Nor is this all. The all-aged stands such as those in the various hardwood regions and the pine regions of the South and West are all too often cut practically clean, sacrificing the young and thrifty middle-aged trees that barely repay the cost of logging or are even cut at a loss, although they would constitute a valuable growing stock for future cutting if left to grow. The trees that are left in such stands are commonly diseased, defective, or of the less valuable species, without promise for future timber crops.

Besides depletion through premature or wasteful cutting, our growing stands of timber are the ones that are bearing the brunt of the forest fire scourge. Not only are such stands usually subject to greater fire hazard and more susceptible to fire injury than mature stands, but in many instances the protection given them is less intensive than that given to merchantable stands.

The maintenance and improvement of our forest capital—our existing stock of growing timber—is the key to the problem of assuring permanent supplies of forest products in time to prevent a serious disruption of our forest and wood-consuming industries. Sweden and Finland have met a similar situation by forbidding the cutting of immature timber, except to thin or improve the stands. Even if such a measure were economically feasible in this country, it would not be politically practical. We should have to deal with the problem in a different fashion.

Public agencies can help toward the solution by handling the public forests in such a way as to build up the largest possible stock of growing timber in the shortest possible time. It should be realized, however, that public acquisition of large areas of deforested land, even if planted up immediately, will accomplish little or nothing toward providing timber supplies for the critical period that will come before the planted stands are ready to cut.

The essential thing is to prevent destruction by fire or by premature cutting, or otherwise, of the young timber now in private ownership, and by every possible means to encourage the owners to build up the quantity and improve the quality of their forest capital. It is in their interest as well as in the public interest for them to do so. Under existing conditions, however, such action is difficult and in many instances impossible because of various economic handicaps. Some of these handicaps can be

removed or at least mitigated by public action. Such action, even though it should entail considerable expense to the public, would be fully justified because of the great public interests at stake.

It is pertinent at this point to inquire why thrifty young timber is being cut prematurely, in face of the overproduction and waste of the usually more valuable virgin timber. The principal reasons are these: lack of understanding of the situation by the owners of the timber; inability to practice forest management because of nonresident ownership and small size of holdings; desire to convert the timber into cash as soon as it has a slight positive cash value rather than run the risk of loss through fire, blister rust, bark beetles, high taxes, etc.; and need for cash by the owners, who can raise it only by cutting their timber.

In order to induce owners to withhold such timber from cutting until it is more nearly mature, it will be necessary for the public to show them that such action will be financially advantageous to them; to eliminate, reduce, or assume at least a portion of the risks involved in holding timber; to provide an agency for supervising the management, particularly of small tracts; and to aid financially weak owners through advancing funds until the timber is ready for cutting. It is believed that most owners, if they understand the situation and if the economic handicaps on timber holding are removed, will voluntarily and in their own interest desist from cutting immature timber, and will thereby build up a growing stock that will help to maintain a steady flow of timber when it is most needed.

For accomplishing the objectives listed in the preceding paragraph, the following federal program is suggested:

1. An intensive campaign of education in each important timber state regarding the economic significance and advantages of maintaining an adequate growing stock of the right kind of timber. This campaign should be directed at the landowners, rather than the general public or the schools.

2. Complete fire protection for all forest land. This will necessarily involve coöperation with state authorities, but federal appropriations for the purpose should be much larger than at present, and there should be much more latitude in allocating the funds to the states where needed, regardless of local contributions. As a general thing, public agencies should provide fire protection without requiring direct contribution by the landowners. The owners, however, should be required to adopt reasonable measures designed to reduce hazards.

3. More liberal federal assistance in combating diseases and insect epidemics.

4. Provision of adequate insurance for growing stands against loss by fire or other causes. If it should be impossible to induce commercial companies to insure such forests at reasonable rates, or to organize mutual companies capable of handling the problem, a system of governmental insurance should be devised.

5. Organization of a central board, which might be termed a Forest Finance Corporation, and subsidiary boards in each important timber state, with the following functions:

a. To advance money to owners for paying taxes, insurance, and other carrying charges on growing timber, particularly on stands approaching merchantable size that should not be cut for some time. Such advances to be repaid with simple interest at a low rate (perhaps

3 per cent) when the timber is cut. The central board and local boards in states where the taxation of forests is on an unsatisfactory basis would use their influence to bring about more equitable taxation of growing forests.

b. To provide fire and other insurance at reasonable rates where such insurance is not available through commercial or mutual companies.

c. To lend money on young merchantable stands, up to the full net value that could be realized by cutting such stands at the time the loan is made. Such loans should be granted on the condition that the timber be left standing until such time as the local board declares it ready for cutting, and that cutting should then be done in accordance with methods prescribed by the board. Such loans would run until the timber is cut (unless the owner should prefer to pay sooner), and should be at a low rate (perhaps 3 per cent) of simple interest. Likewise, loans would be available on selectively cut stands. These loans, by enabling owners needing money to raise it without sacrificing their timber, will encourage them to hold the timber until maturity.

d. To provide supervision or actual management of woodlands at low cost, especially for non-resident owners of small tracts, but also for resident owners who are unable to employ foresters because of the small size of their holdings. Where such service is given by the state foresters or similar agencies, of course the Board would not intervene, and in any event it would coöperate as far as possible with the state forester.

e. Under suitable safeguards, to lend money for long terms at low rate to associations of owners, in order to enable them to organize coöperative forests on a sustained basis and to construct necessary improvements.

f. To collect, compile, and interpret information on the local and national forestry situation, the supply of and demand for forest products, and related matters, and to advise forest owners in relation thereto.

The central board might be composed of representatives of the Forest Service, national forest owners' associations, the Federal Farm Board or the Farm Loan Board, and the general public. The state boards would include representatives of corresponding organizations within the states. The central board should have at its disposal ample funds for current administration and a large revolving fund for advances to owners. This fund should probably be at least \$500,000,000, and might be as much as \$1,000,000,000, and would be allocated as needed among the different state boards. The full amount would probably not be needed for several years after the initiation of the program.

The above program has purposely omitted any provision regarding the extension of public forests. Desirable and inevitable as such extension may be, it is not likely ever to go far enough to solve the problem of a continuous and sufficient supply of timber—certainly not by the time our virgin timber will have been virtually exhausted.

Neither does the program mention the stabilization of the West Coast lumber industry, and the promotion of less wasteful utilization of our remaining supplies of virgin timber. This, too, is eminently desirable. Restrictions upon the wasteful cutting of old timber may

help to prolong the supply of such material, but will not insure that a supply of other timber will be ready to cut after the bulk of the virgin timber is finally gone. The best way to stabilize the lumber and other forest industries of the country, and to stabilize them permanently, is to stabilize the output of the timber that is made available to them. The surest way to do this is to build up and maintain an adequate stock of growing timber. Without a permanent growing stock, a permanent forest industry cannot exist.

PANACEAS, SPECIFICS, AND THE FORESTRY SITUATION

By PHILIP C. WAKELEY

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THIS Year of Our Lord one thousand nine hundred and twenty-nine, and of the Society of American Foresters the twenty-seventh, appears to be darkened by the more or less inky shadow of a vast *Etwas* called The Forestry Situation in the United States.

The Society of American Foresters appoints a committee on this Situation, individuals and associations discuss the matter with varying degrees of apprehension and wrath, the study of it becomes an all-Service project of the United States Forest Service, and a friend of forestry offers a thousand and a quarter of dollars for the best essays on the subject and the best remedies to be applied to the Situation itself. The Situation is evidently held to be bad.

The most fundamental physical fact to be borne in mind in considering the Situation is that, be prices and wood substitutes what they may, the forest knows no substitute when it comes to the economical conversion of air and water, sunlight, soil, and mere useless elbow room, into usable products. Other physical facts essential to the present discussion are, briefly, the distribution, both actual and ecologically potential, of commercially valuable forest types in the United States; the reduction of our original stock of standing timber, to a level well below that which present knowledge indicates is appropriate to our needs; the immediately unavoidable but ultimately unnecessary long haul from lumber-producing to lumber-consuming centers; the huge areas of potential forest land now barren of any tree crop; the deterioration of forest sites through fire, erosion, and other factors; the decreased forest productivity, even on timbered sites of good quality, through lack of silvicultural treatment; the concentration of our conservatively managed forests on our poorer forest lands; and, lastly, the huge drain on our forests by various damaging agencies, of which fire is the most conspicuous and the most directly subject to control.

Partly as a result of these physical facts, and despite the natural blessings of site and species which America enjoys, we are cutting some four times our forest accretion, and cutting to supply mills often misgauged as to size and mislocated with respect to any possible future source of raw material.

Of course there are other physical facts bearing on our problem. Doubtless, too, many foresters will debate the details of those already mentioned. The recent controversy between Woodward and Zon on one side, and Forbes, Wackerman, and Read on the other, concerning the timber-producing power of the southern pine region, is a case in point. So, too, F. S. Baker argues in the JOURNAL OF FORESTRY that we are cutting our timber not four times as fast as it grows, but

only three times. From the standpoint of the present discussion, however, these are mere quibbles. They theoretically increase or decrease the time we have in which to act, but they do not obviate the necessity for action.

Based on and inextricably bound up with the physical facts discussed above are certain other phenomena, mostly economic in nature, which likewise loom large in the present Forestry Situation. The more important of these are the overliquidation—over*production* is hardly the correct term—of timber, especially of Douglas fir, with accompanying waste of raw material, disproportionately high production of low-grade products, and reduction of profits; the brief span of life left to many operations in practically every forest region; the destruction of remnant and second-growth stands and the disturbance of lumber markets by the activities of portable mills; the inequitable taxation of many forest properties and the threat of inequitable taxation of many more; the high cost of protection from fire; and the almost total unavailability of fire insurance for standing timber.

The bearing of these phenomena on the Forestry Situation is obvious. The reduced returns associated with forced liquidation mean reduced resources for the application of necessary forestry measures. Operators struggling to make a meager profit in the last few years of cutting left to them are in no position to practice sustained-yield forestry; and seldom feel able to leave their lands productive for the next comer, even if they wish to. Taxation which imposes on the returns from timber production a burden out of all proportion to that placed on the returns from other enterprises must, wherever it exists, complicate still further our complex and none too healthy Forestry Situation. Protection measures still in the experimental stage seem to leave no funds for experimental cultural treatments.

The results of the phenomena just noted are an apparent economic inability to practice forestry, and an exorbitant cost of holding such timberlands as do not produce an annual yield.

Certain additional facts, mental or psychological in nature, must be mentioned in connection with the physical facts and economic phenomena already discussed.

For one thing, there has been aroused a rather general popular support of forestry. It becomes increasingly easy to get state and federal appropriations for fire protection, forest acquisition, planting, and research.

We still hear the protest of two and three decades ago, to the effect that the lumberman is a natural born devastator and a creature of the devil, who should be curbed by law. Proposals vary and have varied from temperate and rather ineffectual measures to extremely rigid and iron-handed control, such as is impossible even on the national forests, and which in practice would control the lumberman to the point of driving him out of business.

Still another phenomenon, and one symptomatic of possibly very significant changes in the Forestry Situation, is the recent furor about forestry education in the United States. Evidently the qualifications of the forester himself are doubtfully regarded in some situations commonly arising.

Lastly, there should be included, among the obvious physical, economic, and psychological aspects of the Forestry

Situation, the profession's own consciousness, however blurred, of that Situation. However bad affairs may be, some encouragement may be found in the professional forester's discontent therewith.

To sum up, we seem clearly threatened with a timber shortage, or at the very least with a highly undesirable curtailment of our present per capita lumber consumption. Thanks to our natural advantages of soil, climate, and productive tree species, and to the very considerable forests we have left, the Situation is by no means hopeless. The disconcerting fact remains, however, that the professional foresters, presumably best qualified to deal with the matter, are in serious doubt as to what to do about it.

The offer of the substantial prize mentioned at the beginning of this paper implies the hope of some panacea for the Forestry Situation.

Intelligent men are doubtful of panaceas, simply because they have learned that remedies are almost invariably specifics. Men of judgment may concede, perhaps too readily and charitably, the possibility of panaceas in fields of endeavor other than their own; in their own, they know that difficulties must be surmounted and evils remedied step by step, one at a time.

It is not necessary, however, to confine the "stepping" to one man. If enough men can be persuaded to step in the same direction, a trend will be established, the following of which, if it be the right trend, may ultimately have all the effects attributed to the most potent of panaceas. Keeping in mind this matter of steps and trends, let us look at the less obvious characteristics of the Forestry Situation today and see whether there is not some partly hidden but none the less serious factor which might be responsible for our present unsatisfactory conditions and susceptible to our control.

The most significant subsurface characteristic of American forestry today is our totally inadequate silvical knowledge and silvicultural practice. For years our emphasis has been increasingly on engineering, on business management, and on economics, all necessary, to be sure, but bought at too high a price if they have meant subordination of the silvicultural side of the forester's work and obliteration of the one professional characteristic which sets him apart from all engineers and business men and economists. What a forester should have that other men lack is silvical knowledge and silvicultural skill, the technique essential to the handling of that biological complex which we call the forest.

That silvical knowledge and silvicultural skill have been subordinated is shown by an abundance of readily available evidence. The literature on display at any regional forestry congress runs to educational technique, fire line construction, lookout towers, hints on profitable methods of utilization, and a few general rather than specific exhortations anent thinning and planting. It is as though an agricultural fair featured only cash registers and wire fencing. The Journal of Forestry for the past ten years runs strongly to protection, policy, education, mensuration, and economics, with a sprinkling of good articles on nursery technique and planting and a very few titles that have any bearing at all on natural reproduction or intermediate cuttings. The Journal's chief contribution to silviculture has consisted of reviews of foreign literature.

With one or two notable exceptions our recent forestry texts, even including second editions, have been books devoted to specialties other than silviculture, or else general treatises in which the silvicultural sections were more or less cut and dried. We have no "case study" of silviculture even remotely approaching Troup's *Silvicultural Systems,* nor any adequate counterpart of his *Silviculture of Indian Trees.* Toumey's *Foundations of Silviculture upon an Ecological Basis,* which marks a considerable advance in American texts, shows an astonishing dearth of actual examples drawn from the publications and field practice of the American profession at large. The five bulletins so far available of the Forest Service series on timber growing and logging practice in our principal forest regions, while well-executed and admirably suited to the audience and purpose they are meant to serve, are nevertheless so full of protection and economics, and so generalized and elementary in their biological treatment of the trees and types under discussion, that they must inevitably stand a monument to our first toddling steps in silvicultural practice.

The Forest Service, although officially recognizing the importance of marking and the desirability of having it done by seasoned technical men with ample local experience, is too often obliged to entrust most of its marking to temporary field assistants and newly acquired junior foresters. Few private companies, even among those professing an ardent zeal for forestry, do any marking at all. Almost any practicing American forester, granted most of the seed he is collecting germinates, is smugly content to get it from the most accessible crowns, wholly unmindful of the inherent qualities of the parent tree. Our emphasis on brush disposal as a silvicultural practice, the weight we repose on diameter-limit cuttings, and our general pride in sundry state seed-tree laws, all mark our silviculture as puerile still. Too often the administrative forester abandons silviculture to the research worker and both to their own fate thereafter. The one concession many a forester makes to the silviculturist is in the matter of plantations—and then he points with pride to plantations so ecologically unsound that it is doubtful whether they will ever yield merchantable products. As a group we have subordinated silvicultural considerations to the urgencies of fire protection, profitable logging, improved utilization, grazing, even recreation, often accepting this subordination as necessarily permanent.

In short, the profession of forestry in America has come to regard silviculture as a sort of vermiform appendix, to be tolerated so long as it causes no inconvenience, but to be excised the instant it makes any trouble. Judging by the results to date, in reproduction and growth, this all too frequent operation has resembled not appendectomy, but castration.

This wholesale gelding has resulted from general preoccupation, ignorance, and mental indolence. We say: "Manage on such and such a scheme, with due regard to the silvicultural requirements of the new crop"—and then, because of lack of knowledge, real or fancied economic pressure, or sheer laziness, fail to apply enough silviculture to start a new crop. We say: "It doesn't pay to practice silviculture until protection is perfected," forgetting that unless some silviculture is applied there will be, in

many cases, nothing to protect. We decry the possibility of "intensive" silviculture under present conditions, and let the word *intensive,* together with the fact that large areas of forest can receive no cultural treatment for years to come, blind us to the possibilities of *effective* silviculture, sound, though not necessarily intensive, on the areas being logged today.

We have not only lost sight of the vital necessity of silviculture in reproducing our forests and keeping them at maximum production—the crux of the whole Forestry Situation—but have also overlooked the effect of silviculture upon many of our problems in protection and economics. Private and public agencies alike are more willing to appropriate funds for protecting thrifty young stands than for protecting brush fields, and often enough the very measures most desirable silviculturally are most apt to decrease the hazard not only of fire but of insects and disease. The higher yields under good silvicultural practice must render forestry more attractive financially. Indeed, one of the "costs" usually charged against the practice of forestry is merely a safety allowance for slow and incomplete restocking and slow growth, and hence less necessary as silviculture becomes more sure in its results. Even the vexed subject of taxation may be solved in part by silvicultural means; what assessor would value a true selection forest, with only the permissible cut of the next ten years actually of cutting size, and that scattered among a goodly stand of seedlings and saplings, as highly as he would value the equivalent stumpage in an even-aged stand on the same site? Instances could be multiplied indefinitely; the very complexity of silviculture renders it the more able to supply a host of specific remedies for various ills of our complex Forestry Situation.

It is not meant to imply that America lacks notable examples of silvicultural practice. Still less is it intended to suggest that we should advance our silviculture at the expense of fire protection or any other pressing phase of activity; the terrific fire season of 1929 alone makes such an idea unthinkable. We must hold the ground we have gained in protection, in legislation, and in economics.

We must do more than hold our ground. Our present fire protection program undoubtedly needs tremendous expansion. We need more public forests, for reasons of strategic location as well as on economic considerations based only on area and volume production. We need a general tuning up of our higher education in forestry, and a very marked increase in the number of men given a vocational forestry training.

These, however, are not cure-alls for our Forestry Situation. They are merely details in the solution of the multitude of problems that surround us. There is no panacea here. Furthermore, placing our primary emphasis on these non-silvicultural activities has left us with a Forestry Situation on our hands. Who will deny that if we had lost as much sleep over silviculture these past two decades as we have over fire, we would have already taken the much discussed "next step" in getting out of our national forestry predicament? As it is, we find ourselves groping in the dark.

Moreover, what good are increased government ownership of forest lands, increased appropriations for forest planting, compulsory forestry for private owners, private forest subsidy, or blanket

protection of the whole forested area of the United States, unless we have workable knowledge of the necessary silvicultural principles for our multitude of forest types, and a large body of appropriately trained men, from our present highest technical grades down through rangers and woods foremen, to apply this knowledge?

If any one thing can better our Situation, it is to change the trend of professional forestry thought in America and bring silviculture prominently into the foreground as an essential means to the various ends sought in the practice of forestry. We must have more specialists in silviculture, and silviculture must become the avocation of specialists in every other line. This will mean work. And the hardest work men do is to adjust themselves to new ideas. Foresters who are showing a profit now and hoping that something will come from somewhere to seed in their lands, will naturally groan a bit at having to take an occasional money loss to show a good stand of seedlings. Experts in road building may at first feel little interest in mycorrhiza. Administrators who have settled into a comfortable routine in one region will resent the effort needed to familiarize themselves with the minutiæ of silvicultural practice in other regions, in a really conscientious effort to improve that in their own.

Such a renaissance of silviculture is not simply a matter of perfunctory professional policy. Fundamentally it is a matter of individual self-discipline and individual action. It can take place only as every forester sees and feels the need; learns or rediscovers the intellectual stimulus silvicultural work affords; bends his energies to observation, study, experiment, and a kind of silvicultural crusade; ferrets out the necessary silvical facts and, with all the ingenuity and persistence at his command, develops his findings in practice; lives, moves, and has his being in silviculture; eats it and breathes it and dreams of it when he is asleep. Only in this way can we develop an adequate American silviculture in time to meet our needs.

With such a renaissance, we bid fair to overcome our physical and economic handicaps in the practice of forestry, and not only assure our own country a sufficient supply of forest products, but contribute our quota toward the world supply. Without it, our Forestry Situation is dark indeed.

THE NEXT STEP FORWARD IN INDUSTRIAL FORESTRY

By VICTOR A. BEEDE
Quebec

THE personal opinions expressed here are those which I find myself holding after twelve years in the woods of the Province of Quebec, with frequent assignments in the New England district.

In my opinion, the next step forward in the silviculture of the northern spruce region is an adjustment of the size, distribution and character of the cutting units to correspond to their availability to market—some, in favorable zones, to receive intensive treatment; some to be handled with a fair degree of intensity; and some, on account of relative inaccessibility, to be cut clean without provision for renewal, except as Nature herself provides, or perhaps not to be operated at all for the present.

Let us start with the conception which seems to me fundamental, that the degree of forestry practicable in any region depends upon distance from market. That is why on woodlands within, let us say, the eight-cent freight rate of market, use can be made of methods which would be manifestly out of the question on more remote areas. Centers of population furnish a better market for hardwoods and smaller materials, and allow a far closer utilization. This condition is best realized on woodlands near the outskirts of cities and towns. One finds it developed to an extraordinary degree in the municipal forests of Europe. It is to this class of lands that cleanings, improvement cuttings, and thinnings are likely to be restricted for the present, for it is safe to say that such methods as these are unlikely to prevail in routine fashion on the comparatively remote lands which constitute the bulk of the northern spruce forest.

Intensity in forest management means the number of cuttings which can be made over the same area before the final crop is harvested, and how often these cuttings can be made. The point I wish to make is this: Do economic conditions allow us to watch the young growth carefully, nurse it through the juvenile stage by cleanings and release cuttings, thin it judiciously and often during its period of rapid height and volume growth, and finally harvest and reproduce the crop by a series of carefully planned cuttings covering a short period of time, perhaps twenty years? Or, does poorer accessibility restrict us to the use of strip cutting or some other simple measure? Or, do economic conditions compel us to harvest the crop all at once and to leave Nature to restock the land in due time in her own laborious but reasonably sure way? Or, does good judgment indicate that we should resort to all three alternatives when and where opportunity exists?

Foresters are in error if they conceive that such a carefully planned and skillfully executed program as that suggested as the first alternative is applicable to all

the vast spruce forests of the northeastern United States and Canada, just as they would be if they held that the wonderfully intensive modern truck gardening methods are applicable to the vast wheat fields of the West.

Those of us engaged in industrial work have to be alive to the fact that, under the stress of modern industrial competition, only such measures as are essential to keep the forests generally productive are likely to survive. A fine spirit has been shown by our foresters and has accompanied the development of forestry in this country. Along with it is a tendency to regard its development as something akin to a crusade, with forestry itself as the object to be everlastingly striven for and attained at all costs. This inclination must be modified in practice, for in industrial work at least forestry is not an end in itself. It is rather an instrument, a means by which another end is sought, namely the maintenance of our great industries on a sound and permanent basis.

To insure a continuous supply of wood from a given region some simple, workable silvicultural expedient must be decided upon which is in harmony with business conditions and with modern logging methods, and which can be applied on a broad scale. This is not the forestry that seeks the maximum production on every acre; indeed some acres will escape production entirely in the extensive manner in which these operations must be conducted. A twofold object is in view—to harvest the crop as cheaply as possible, and to keep these lands far and near generally productive.

Even in Europe, where one rightly expects to find the highest degree of forest management, one can indeed see just as simple forestry if he gets far enough away from the centers of population.

The restriction of the cut by the application of a diameter limit, providing that all trees under a certain diameter must be left uncut, is an attempt at such a simple measure. This is the official practice on the Crown lands in the Province of Quebec, and has the virtue of being at least workable. It is far from satisfactory, however, for reasons with which we are all familiar. It cannot rightly be called a silvicultural measure. It is just better than nothing; yet it is surprising how well in some instances the forest will be renewed when cut over in this way.

What has forestry to offer to meet this situation?

The very heart of forestry is silviculture. A very distinguished gentleman has characterized it as the pivot of the whole forestry business. It has been well defined as the raising and harvesting of repeated crops of timber, of which the word *repeated* is of course the important one. In a broader sense perhaps forestry may be considered to be the sum total of human knowledge about the forest—its beginnings, its life history, its diseases, its predatory insects, the game which it shelters, the habits and requirements of the various tree species, the structure and properties of its woods, its soils, its physiology, the harvesting of its crops. But do not allow all this, commendable and necessary as it is, to obscure the immediate issue. It all boils down to the art or business, or whatever we choose to call it, of *raising repeated crops of timber,* and unless we are handling our forests with this end in view, we are not practicing forestry, nor are we seeking to keep

the supply of raw material for the industry on a permanent basis.

In order to accomplish this, something has to be done to ensure and safeguard the reproduction of the forest. Let us recall that European experience, which is not adaptable unreservedly to American conditions, but which has tended to show the way in fundamentals, has resulted in the development of certain theoretically well-defined reproduction methods of cutting:

1. *The selection method,* with its removal of single trees or groups of trees—a comparatively intensive method applicable in regions where young growth is slow or uncertain of establishing itself, or where a forest cover is needed for the regulation of streamflow and watershed protection; or by owners of small lots where timber production is a desirable but not a prime factor, and where the æsthetic motive may be prominent.

2. *The shelterwood method,* with its preparatory cuttings, its seed cuttings, its removal cuttings—a whole series of partial cuttings that remove the entire stand within a period of years which is a small fraction of the rotation age.

3. *The seed tree method,* by which 10 to 20 per cent of the volume of the stand may be left as isolated individuals or groups of individual trees—a method not widely adaptable to the shallow-rooted spruce and balsam fir as we find them in the north today.

4. *The clear-cutting method,* with its complete removal of the timber on restricted areas, and its various modifications—clear cutting in alternate strips, clear cutting in progressive strips, clear cutting in groups—variations by which the timber is removed, and restocking provided for, in the manner suggested.

The attention of foresters has long been directed to some form of the clear-cutting method for handling pulpwood forests. This is obviously adapted to the shallow-rooted and light-seeded softwood species of the northeast, and is most nearly in harmony with the economic conditions and logging methods in that region. Granting certain disadvantages of the clear-cutting method, it is not necessary to enlarge upon its manifest advantages as a means of combining inexpensive operating with a reasonable assurance of general restocking.

Especially, to approximate a reasonable application of some form of the clear-cutting method, the cutting units, in other words the job lay-outs, of a smaller size than those now generally in use, should be distributed over a wider territory, to ensure a greater chance of restocking. This is indeed the present tendency, and it is along this line that I expect to see important developments in silviculture. I have in mind also one excellent operation where the timber has been cut in strips across the path of the prevailing winds.

Here are the two sets of facts—on the one hand are conditions calling for measures which are practicable and will ensure repeated crops; on the other, several silvicultural expedients are at hand. It seems to me that it does not require a great amount of imagination to bridge the gap between the two.

This in my opinion is the nature of the next step forward—measures which, while far from perfection, will be satisfactory from an economic standpoint, and will permit of refinements as time goes on. It seems to me the most important single fact in the forestry of the Northeast today.

A LETTER TO FORESTERS[1]

THE destruction of the forests of America has been a long-drawn out tragedy of waste. Now we face the danger of a moral tragedy also: that the foresters of America will accept that destruction and by silence condone it.

Forest devastation is the heart of the forest problem. Yet on this vital issue we are drifting. Some of us are lured by the illusion that forest owners will voluntarily end forest devastation in spite of the overwhelming evidence, after half a century of public protest, that the progress in this direction is almost negligible. Some of us are lulled to inaction by a lack of faith in the possibility of remedying the evil. And now, to justify failure to meet the real issue, comes the excuse that after all timber is not going to be much needed. If the grapes cannot be reached, it is consoling to think they are sour.

It is not too late to adopt a policy of mastery instead of drift. But the first step is to recognize that the fate of our forests depends in large measure on the mental attitude of foresters, here and now, toward the problem of forest destruction.

The profession must squarely face the problem of forest devastation. In every field of human activity, failure to meet responsibility is implacably punished by spiritual decay. Failure to grapple with the problem of forest destruction threatens the usefulness of our profession. We must cleanse our minds of apathy and doubt; and through a rebirth of faith in forestry and a reawakening of all our moral and mental energies, we must set the forestry movement on the path to its goal.

The profession of forestry in America was born with high ideals and great purposes. It has fought many a bitter fight against heavy odds. It has won magnificent victories. From the very first its guiding spirit has been that of public service. The profession can be proud of its history.

Today foresters are confronted with as great a challenge as any they have met in the past. Will they meet this new challenge in the old spirit? There was never a more compelling call for constructive leadership in forestry than now. The forests of America were never more in peril than at this moment. We are headed toward forest bankruptcy. What forestry there is on private lands is too little to exert the slightest effect on the vast problem of our future forests.

Today, after fifty years of exhortation and protest, the bulk of our forests are still being slashed and ruined, the second growth even more disastrously than the old growth. They are being stripped of their timber with no provision for regrowth. This is forest devastation. Our public forests excepted, forest destruction holds unchecked sway.

The duty of the foresters of America, with faith in the forest and in the nation,

[1] This letter was originally circulated with the notation "not for publication." It is now printed, together with several replies, at the request of many members of the Society of American Foresters and with the permission of all of the signers.—ED.

is clear before them. It is to destroy forest destruction in the United States.

For the safety and prosperity of our country, forest devastation must be stopped.

There exists today no program for dealing on a large scale directly with forest devastation. Except for the creation of public forests, the main attack on forest destruction has hitherto been indirect. It consists chiefly in encouraging private forestry by forest fire protection, research, and tax reform.

We recognize the splendid work done in these fields. But we also recognize the obvious truth that these efforts are not enough. The forestry movement must now be reinforced by an organized nation-wide program on the part of public agencies and of forest owners and industries to abolish destructive logging.

The cure of deforestation must be sought along two main lines; public measures to prevent forest devastation and a greatly increased program of public forests.

With such a background of control to assure forest renewal, the whole forestry movement would acquire a new vitality and energy. Today with the general prevalence of destructive logging many of our forestry activities are kept from full fruition. To what end a vast and expensive system of fire control if the forests it protects are to be destroyed by the axe? To what end a great program of forest research if the forests to which it should minister are to be destroyed? The future of our forests, of our forest industries, of organized forestry agencies, of education in forestry, and of the profession itself is all dependent on stopping forest destruction.

World-wide experience shows that in the absence of public control few private forests escape destruction. Most of the older countries have public control of private forests, from the well-nigh complete control of Sweden, Japan, and Switzerland, to the partial control of France and Germany. In most countries, public control of forests needed for protecting mountain and river systems is taken for granted.

When private property is so used as to lead to public injury, public regulation must be invoked. In the United States, public regulation is exercised over many forms of property, such as railroads and other public utilities, urban buildings, and interstate commerce. When the very existence of a great resource like our forests is at stake, and the results of present abuse may be felt for centuries, it is even more necessary to declare the public interest supreme.

The forest problem is a national problem. It cannot be solved without federal regulation. There is a wide and unquestioned field for state regulation, but it is idle to rely on independent action by forty or more states in time to save our forests. A great nation can and must invoke the powers necessary to save itself from the disaster of forest destruction. The Supreme Court of the United States in the recent Migratory Bird case has said: "It is not lightly to be assumed that in matters requiring national action, 'a power which must belong to and somewhere reside in every civilized government' is not to be found."

The silvicultural basis for control has already been laid by the Forest Service in the nation-wide "Timber Growing and Logging Practice" study. The original purpose of that study was to define

the simplest measures necessary to prevent forest devastation. The next step in forestry is to put these measures into effect in every forest region of the United States.

The forests needed for the protection of our mountain and river systems are in need of special attention. Ultimately they should be largely in public ownership, but meanwhile their devastation must be prevented by public control.

Public regulation to prevent devastation is the most urgent need in forestry. Nevertheless public regulation would not in itself be a complete or in the long run a wholly satisfactory remedy for devastation. We need a great expansion of public forests. Among the many reasons for such a program we must give special attention to the pressing tendencies in forest land ownership. Private cut-over lands are being abandoned on an immense scale. They are coming back on the public whether it wants them or not. The breakdown of private ownership is creating a new public domain. If these lands are to be saved from complete devastation and from becoming an increasing burden on the community, they must be definitely organized and handled as public forests.

There must be not only more national forests, but especially more state, county, and town forests. The problem of forest acquisition is altogether too big for any one public agency. There is room and to spare for all, without conflict or overlap. But to prevent conflict and to stimulate public ownership of every character the federal government and the states should work out a joint program nationwide in scope and amply financed.

It goes without saying that all other current forestry work should be properly developed. Public support of forestry should be proportionate to the greatness of our forest resources and the vastness of the problem of their preservation.

This statement is not a forest program. It is a discussion of a few principles which, in our opinion, are basic to the real advancement of forestry. In brief, we believe that:

Forests are now and always will be indispensable to civilization.

Forest devastation goes on unchecked.

Forest devastation cannot and will not be stopped by voluntary effort of forest owners and industries.

The only way to stop forest devastation is by public control.

Both federal and state governments have ample power for such control.

Forest devastation must be stopped.

It is the duty of the foresters of America to stop it.

George P. Ahern,
Robert Marshall,
E. N. Munns,
Gifford Pinchot,
Ward Shepard,
W. N. Sparhawk,
Raphael Zon.

Washington, D. C.,
February 7, 1930.

OBSERVATIONS ON THE "LETTER"

By R. C. HALL
New Haven, Conn.

A CIRCULAR entitled "A Letter to Foresters" deals with the very important subject of forest policy, which is now under consideration by the Society of American Foresters in connection with the report of the committee on this subject.

Careful reading of the "letter" suggests that the signers are alarmed not so much by the prospect that forest destruction will be accepted by foresters, as by the fear that the remedies they think essential will not be accepted. Like all "fundamentalists," they identify the only true religion with their own particular creed, and give scant credit for sincerity to those of different opinion. They imply that foresters who are impressed by the decreasing demand for wood are crying "sour grapes" to excuse professional failure. Apparently they do not see any wisdom in profiting by the experience of the agricultural experts and want us to work blindly for production regardless of prospective markets.

The "letter" describes itself as a discussion of principles. Nevertheless two measures are very specifically advocated; regulation of cutting on private forest lands by the federal government and expansion of public forests. The former proposal is the core of the message. "The forest problem . . . . cannot be solved without federal regulation."

That federal regulation of cutting on private lands is either possible or desirable is open to very grave doubt. Possibility of such regulation is contingent on passing legislation affecting property rights and the jurisdiction of the states that would be generally regarded by the American public as revolutionary. It is also contingent on the approval of such legislation by the Supreme Court.

Foresters should not be misled by fragmentary quotations from the decision of the Supreme Court in the case of the Migratory Bird Treaty Act.[1] If anyone is inclined to take these seriously as supporting the constitutionality of federal regulation of forest lands, he should read the full report and see for himself how little ground there is for such an opinion. The case concerned a claim of exclusive authority asserted by the State of Missouri to regulate the killing and sale of migratory birds within its borders. Private property rights were not involved in the remotest degree. The *physical* impossibility of protecting these birds by state action, and the shadowy character of the right of the state over them, were evidently large factors in the decision. In its opinion the Court said:

"To put the claim of the state upon title is to lean upon a slender reed. Wild birds are not in the possession of anyone, and possession is the beginning of ownership. The whole foundation of the states' rights is the presence within their jurisdiction of birds that yesterday had not arrived, tomorrow may be in another state and in a week a thousand miles away. . . . . Here a national interest of very nearly the first magnitude is involved. It can be protected only by

[1] Missouri *vs.* Holland, 252 U. S. 416. Decided April 19, 1920.

national action in concert with that of another power. The subject matter is only transitorily within the state and has no permanent habitat therein."

When trees take wing and flit from Florida to far Ontario the Supreme Court may be counted on to confirm the power of the federal government to regulate their exploitation. Otherwise, some amazing possibilities have been overlooked since this " recent " case was decided early in 1920. If individual rights and state prerogatives may be swept aside by the simple expedient of invoking the treaty-making power, why not solve other vexing problems of international importance, such as child labor and conflicting divorce laws, not to mention forest taxation, by negotiating treaties with Canada?

Even if it were feasible, the desirability of regulating the cutting of forests by the federal government may be challenged. Are foresters sufficiently certain of what measures are essential and sound to warrant imposing them on private owners by weight of authority? Not all, and perhaps not many, of those responsible for the conclusions of the " Timber Growing and Logging Practice " studies would be willing to take that position. Can any kind of silviculture that is economically sound be developed by compulsion? Is it possible to devise legal restrictions on cutting that will apply equitably as between different operations? Most lumber producers have little surplus to play with. If the methods imposed were unprofitable, the results would be bankrupt lumber companies and more tax-delinquent lands. Where they were profitable, there would be no need of compulsion, for in such case better and quicker results would be obtained through a policy of coöperation.

The administrative difficulties in the way of enforcing silviculture on unwilling forest landowners throughout the United States are appalling. Endless unhappy possibilities are involved; friction between foresters and lumbermen, litigation, and unfavorable reaction against the whole forestry movement. On the other hand, when forestry practice reaches the point that some degree of public regulation will receive the willing coöperation of a majority of forest land owners as a protection against unfair competition or because coupled with other legislation beneficial to their interests, the situation will be different. Such regulation as may then be found desirable will probably have to come through the states, both for constitutional reasons and for coördination with taxation and other measures unquestionably within their sole jurisdiction.

Most foresters would probably agree that a greatly increased program of acquisition of forest lands by federal, state, and local governments is desirable. The need for protection forests may be met by such a program. Where serious damage to watersheds is threatened by cutting and fire on private lands, the right of condemnation may be used to secure immediate control without entering upon any unnecessary attempt to regulate private lands. The vigorous extension of public ownership of forest lands should not be handicapped by tying it up with a program of federal regulation.

Aside from the portion dealing with the specific proposals just discussed, the " letter " reads more like a call to arms than a discussion of principles. The principles of forest policy can best be

considered, not in the heat of emotion and professional pride, but in the light of facts and sound reasoning. Questions such as the extent to which our land area should be maintained in forest, the types of ownership and kinds of forest that are best adapted to various situations, and the investments, public and private, that can profitably be made to secure these forests, can be met with only partial or tentative answers at this time. To settle them with some degree of finality we must have more facts, such as will be developed from land utilization studies, forest surveys, and other research projects under way and contemplated.

In the meantime, since in most regions fire prevention alone will stop forest destruction, let foresters keep up the fight on that line until forest property is insurable at reasonable rates. There is enough to do for the cause of forestry in that and other vital matters without wasting enthusiasm and energy in chasing the rainbow of federal regulation. It is well to face the fact that forestry will be effectively practised by private owners only when and where forestry will pay them a reasonable return. The way to promote forestry on private lands is to work for adequate fire protection, appropriate taxation, and more knowledge of how to make forestry profitable. There is no royal road to private forestry.

AS I SEE IT

By R. S. KELLOGG
New York, N. Y.

FORESTRY is the growing of timber for use and foresters are those who grow it. The Society of American Foresters is supposed to be an organization of men qualified by training and experience to direct and assist in the multitude of problems involved in the growing and using of timber. Membership in the Society is assumed—as in other organizations of technologists—to indicate a certain degree of accomplishment and standing in the profession.

The Society was created "to advance the science, practice, and standards of forestry in America." Its membership as of November, 1929, consisted of 8 Fellows, 663 Senior Members and 888 Junior Members—a total active list of 1559. As nearly as can be determined from their listing, 6 Fellows, 464 Seniors, and 548 Juniors are in some form of public service, leaving a total of 539 of all grades in private employment or otherwise dependent upon their own resources. It is inevitable that among such diversity of affiliations there should be fundamental and perhaps irreconcilable differences of opinion.

The Society should not be an institution for propaganda nor used for the advancement of personal theories of public policy. To the extent that it is so used, the Society will be torn by internal dissensions and its proper functions obscured. Propaganda should come from organizations publicly known to be subsidized for such purposes. It has no rightful place in a scientific organization.

The problems of forestry in America are limitless and ever changing. They are as varied as topography, climate, species, and fashion can make them. There can be no one solution and no one policy. There is and can be progress through study, research, and invention, with the results intelligently applied in the light of ascertained economic conditions.

As an open forum for the presentation of opinion and results, the Society is of great value to those who are trying to do the jobs of forestry. There is no moral tragedy in disagreement among scientists and technical men. Such a charge is pure childishness, as the calling of names always is.

As a member of the Society for many years, I hope that there may be no perversion of its basic purposes.

IS FORESTRY A RELIGION?

By F. W. REED
Washington, D. C.

IS FORESTRY a religious creed based on a fundamentalism which may not be questioned? Is our forestry profession a priesthood whose members may study and work to support the prescribed doctrine of faith, but who may not use their increasing knowledge nor their better understanding of the facts to modify their previous point of view, or to replace it with a new one which more nearly fits conditions as they actually are? Is forestry no longer a science, based on a search for the truth? Is the truth forbidden, unless it happens to coincide with our preconceived theories?

Frankly, this "Letter to Foresters" has me puzzled. In it I read the almost direct implication that he who fails to support its tenets of faith, *in toto,* is a moral degenerate, if not worse, and fit only to be read out of the profession. Of the seven men who signed the letter, six are old friends with whom I have worked and played down through the years. One of them was my leader during one of the most absorbingly interesting periods of my professional career. Of the seventh, it is no doubt my misfortune that I lack his acquaintance; he presumably must be imbued with the same high idealism and sincerity of purpose as his associates. I have respect for these men, for the professional work they have done; I value their friendship, for the men that they are; but to retain this friendship must one sacrifice his own self-respect by repudiating his own knowledge of the facts and by suppressing his own honest interpretation of them? Must one instead subscribe blindly to a prescribed dogma, which lightly disregards certain well-known and essential facts, and forswear all right to his own opinions, lest he be charged with "spiritual decay" and accused of dishonest motives?

Surely, if this be their intent, the authors of this letter are demanding much of the profession, and of their friends. What is the membership of our

Society of American Foresters that it would rise *en masse* in response to such a call?

We have a few members who are men of independent means, who are working at some phase of forestry for the pure love of it, and who are absolutely free to develop and express their own opinions. Such men are in a position to contribute mightily to the progress of forestry—if their point of view is sound. Their position and opportunity are highly to be envied. I could wish I were one of them.

We have next a larger group filling high places on some public, or quasi-public, payroll, from which vantage point they can view the forest situation and its needs unhampered by any sordid financial considerations. They are free to develop theories of how the forest owner should manage his property in order to keep it in good silvicultural condition for the public benefit, and are not personally concerned, as is the forest owner himself, with the pressing problem of making the property pay dividends. Such men also are contributing much to the progress of forestry—so long as they are tall enough to keep their heads in the clouds and their feet upon the ground at one and the same time; to recognize fully the importance to the public of adequate forest conservation, and simultaneously to retain a sympathetic understanding of the forest owners' difficulties and obstacles. That so many of our public foresters possess the necessary stature to do this is a matter of congratulation. Their position, however, is not quite so enviable as is that of the independents; they cannot always give vent to their own opinions with absolute freedom lest they run counter to the official policies of their organization.

By far the majority of our Society's members have trained themselves in the profession as a means of livelihood, just as other men take up law, or medicine, or engineering. It is not to be expected that any but the exceptional few will be men of independent means who can work for the pure love of the cause, nor is it practicable for too many of them to enter the public service or the educational field. An increasing number of them each year finds a more profitable opportunity for their forestry knowledge and skill in the business field, in the forest industries, and in the operation of private timber properties. Amid such surroundings the forester inevitably must look upon forestry as a business proposition, to be practiced with a due regard for financial profit, rather than a public cause to be striven for with something akin to a religious zeal.

What the business forester's response will be to the appeal in the "Letter to Foresters" is a matter of moment. He already constitutes an influential element in the profession and in the membership of the Society. His number is increasing yearly. It is worth noting that no business forester's name appears among the signatures to the "Letter." We have, it would seem, in our profession two kinds of foresters: first, the forest idealist who sees things as they ought to be, and looks upon forestry as a cause to be worked for; and second, the forest pragmatist who takes things as they are, and looks upon forestry as a business to be worked at. (I use these two terms, "idealist" and "pragmatist," strictly in their original sense, and distinctly do not write into them any of their secondary disparaging or derogatory meanings.)

Undoubtedly forestry is both a cause to be worked for and a business to be

worked at and there is equal room in the profession for the idealist and the pragmatist. Each can help the other to avoid an extreme that in either case would hinder rather than expedite progress toward a commonly desired end.

But if the idealist through enthusiasm for his ideals should develop a religious zeal that would lead him to accuse his more pragmatic fellows of spiritual decay and of disloyalty to the cause because they do not follow him, is he not playing them a bit unfair? Is he not driving from him the very support he should seek to win?

Self-confidence, and the courage of his convictions, are qualities to be admired in any man. But when they become a self-conceit which refuses to admit the existence of new and better knowledge, and denies the right of others to their own honest opinions, do not these virtues then become a vice?

DE-BUNKING FORESTRY

By C. STOWELL SMITH
Washington, D. C.

FOR thirty years the general public has held the belief that forestry is something intricate and mysterious. Probably this was brought about through observation of the forestry profession in action. Several forest schools of the highest standing have together turned out a considerable number of professional foresters over this period, who have scattered throughout the forest regions of the United States. Most of these men have better than average general education as a foundation for their forestry education. The majority hold masters', and not a few doctors', degrees. They represent just as high standards of training, character, and ability as are found in other leading technical professions. Along with their technical training, however, the foresters of the United States absorb also something that is lacking in many other professions, namely, a great ideal and a spirit of altruism and service. It is true that some men have entered forestry solely to earn a living but not a few are in it because of the opportunity it gives them to accomplish something worth while for the public good.

Forestry came to this country from Europe, or put in another way, a few far-seeing, able men, seeing the need for forestry in this country, went to Europe, absorbed what they could, and brought it back with them. Gradually American forest practice has developed, based upon local conditions, but there still remains a strong European tinge to the thinking applied by foresters to their local problems. Dense populations and a stringent want for wood for fuel and lumber are responsible for the intensive forest cultivation in the countries from which our early forestry textbooks and practices took their cue, and upon these books we have largely depended in training men for the forestry profession.

As against the European conditions we find in the United States large areas of idle land, some of it agricultural in char-

acter, and a relatively small population which makes impossible the close utilization so characteristic of our European neighbors. The problem with them is to develop to the utmost their land and forest resources in order to support their present populations. With us it is not a matter of present population at all, as we still have supplies of both land and timber in comparative overabundance. Our problem, if we have one, is to plan for future populations 100, 500, or 1,000 years hence rather than for present needs. This difference has never been clearly understood and the misconception of our position is largely responsible for the great ideal that today actuates so many professional foresters to do their " bit " in averting a predicted timber famine, actually scheduled several times but not yet appearing.

Recently a small group of professional foresters has revived the great ideal in the fear that some of their colleagues are slipping from their time honored beliefs. To encourage this latter group in retaining open minds and in refusing to be stampeded away from the facts, it is necessary to examine this latest appeal to the profession.

The forests of America have not been " destroyed." It is true that substantial portions have been removed to make room for agricultural development and other portions have been exploited to furnish homes for men, animals, and equipment and lumber for the raw material of industry. The waste, that is, the material which was burned or allowed to rot or otherwise not utilized, was indeed enormous. So has been the waste of coal, metal, oil, and particularly soil values. The mine operator, removing only the coal which was profitable, and leaving behind the balance for all time; the gold miner recovering but 50 per cent of the metal because the other 50 per cent would cost more than its value; the oil producer bringing in a well and draining a pool in advance of any market demand; and the farmer exhausting his soil without attempting to restore it through fertilization,—all represent a tragedy of waste, the latter the greatest waste of all because food is a paramount necessity. With the surplus of the time a more economical utilization was not possible.

What is waste? Does it mean that every bit of coal, gold, wood substance, etc., must be utilized? If *cost* is to be disregarded it is easy to visualize a use by somebody somewhere of everything on earth providing the producer thereof is agreeable to absorbing a loss in delivering it to the person who can use it. Apparent wastes are all around us in everything. If every private automobile on the street carried a full complement of passengers instead of being operated at about one-fourth or one-fifth capacity, what a colossal saving would result,—a saving in time, in traffic congestion, in human lives, and in capital invested in metal, rubber, and even wood. Yet few characterize these wastes as " tragedies." These instances could be multiplied a thousand-fold in everyday life. They are regrettable but not hopeless.

Evolutionary processes are at work in society that tend to correct these apparent wastes just as fast as conditions warrant and demand. Now that we have more farm land than is necessary to feed our present population is no reason for abandoning the profession of farming. On the contrary, it simply means that the farmer must buckle down and revise his methods to suit what markets are avail-

able. If he cannot produce a profit on corn, maybe he can on rabbits. So with the forestry profession. No forester need be downhearted if it cannot be proven to his satisfaction that the country is facing a timber famine. There still remains a tremendously wide field of usefulness to exploit. Undoubtedly things can be done for and with our forests that nobody has yet dreamed of. Unlimited research lies ahead. I have absolute faith in the forestry profession and its ability to take full advantage of its opportunities. But it, like the farmer, cannot afford to grow corn where rabbits are the profitable product.

The term "moral tragedy" needs definition. If it means the failure of the foresters of America to fight for a cause without regard to facts, that is one thing. If it means the failure to make a persistent and well-planned effort to get into effect such forestry practice as is known to be economically sound under our own conditions, that is another. Does a forester fall in repute because he carefully analyzes the facts now available, and tries to keep an open mind on those things which are only matters of opinion, until proven?

The heart of the forest problem really is, first, the need of the American public for forests, and second, what it has available to meet that need. Nobody has yet answered the first question. Now, after many years of conversation, we are trying to answer the second, but probably will not have the answer in less than 10 years. Whatever drifting has been done was during the past 25 years when the forestry profession neglected to ascertain these two facts fundamental to a forest policy.

As to the illusion about what forest owners will or will not do, there is no record of a single instance of a forest owner refusing to install recommended forest practices where he has been reasonably shown that he could profit thereby. And by "reasonably shown" is meant the same assurances that would be required in any other type of business enterprise. If forest owners are expected voluntarily to end so-called "forest devastation," regardless of cost and on a gambler's chance, theirs becomes a philanthropic enterprise.

Actual statistics reveal a decline in the annual lumber consumption of from 46 to about 34 billion board feet in spite of increased population, industrial expansion, and efforts to promote the use of lumber. Is it "sour grapes" to pause and examine the evidence before trying to pick them?

It is probably correct to say that the fate of our forests depends in large measure on the mental attitude of foresters. It is decidedly essential, therefore, that this mental attitude be sane. The time has passed for fanatical attempts to arouse emotions. The professional forester has been fed on plenty of high ideals and purposes and has finally arrived at the conclusion that a diet of cold facts is adequate for present-day consumption—and more nourishing. He has exhausted emotional appeals with the net result that after 25 years of earnest preachment he has come to the point where he admits that the profession is in a rut.

My own history illustrates my point. In 1916 I left a federal position to become closely identified with the lumber industry. I promptly received a letter from a leading forester in which he volunteered the advice that I had reached

the parting of the ways, that I had only two choices: one, to take a strong and persistent stand for forest conservation in accordance with the high ideals of the profession regardless of its consequences; or, two, to be dominated by the destructive forest practices of my employers and to go their ways, thus losing forever my professional standing. I replied that I refused to be placed in either position; that my close association with lumbermen while working at my forestry profession had firmly convinced me that the best way to secure sound progress in forestry on private lands was through men occupying positions like my own who were able gradually but surely to introduce such forest practices as were sound. Needless to say, a reply to my letter was never received. Experience amply justified my belief. Now, 14 years later, comes a call to the whole profession to lay aside apathy and doubt and be reborn in faith. This savors of the revival service that was held over me in 1916 and which fortunately did not take.

I trace a substantial and major portion of what progress has been made in western forestry to men like myself who refused to stand up and recite a creed ready made and handed to them. We retained our ability to contact those needing contact in order that around the table and after full discussion there might develop a spirit of coöperation to be translated into fire protection, less destructive logging, more seed trees, and other tangible things on the ground but seldom on paper. We made progress in those directions in which we could prove the course is worth the cost. Carloads of bulletins on forestry have been written but little actually put into practice except through personal contacts with the lumber industry, not by ministers of the gospel of spiritual redemption, but by men who could appreciate the value of a dollar and talk in terms of profit as well as love of mankind.

Having lived through the many years during which the forestry hosts were encamped on one side of the fence and the lumbermen on the other, each firmly convinced that their cause was the only just one, and having had some little part in getting patrols from the two armies to fraternize, I naturally deeply regret anything that may cause both to dig in deeper and get their reserves in readiness. I have seen pretty good forest practice installed by the manager of a lumber company as the result of salesmanship on the part of his forester opponent on the golf course, not because the manager was convinced that there was a profit in it for his company, but because he felt the man he was playing with was sincere and that, in spite of the uncertainties, he might get out without a loss. What a tragedy it would be if this sort of thing should be destroyed, not only a moral tragedy but a physical one, with a fair chance that a substantial amount of the lumber industry's support for fire protection on cut-over lands and other important safeguards to the future forests might be withdrawn.

I know that some of the most important forestry legislation in the western states was made possible through the support and active interest of the lumber industry, and *never would have been passed* over its opposition. I know that even federal appropriations for the support of organizations like the Forest Service might encounter some difficulties if the lumber industry should organize against them instead of for them, as has

always been the case. It should be constantly borne in mind by the forestry profession that the so-called "magnificent victories" it has won have resulted from coördination of the efforts of separate armies of various creeds welded into a fighting whole, rather than the efforts of a small band of possibly well-meaning but over-zealous fanatics.

There is no question that there exists a compelling call for constructive leadership, a leadership which will inspire the solid support of all intelligent citizens and not a leadership which will result in desertion from the ranks of those portions of the army that are essential to get the leader somewhere in his campaign. There is grave danger in the latter.

If, "after fifty years of exhortation and protest," there exists no program for dealing on a large scale directly with "forest devastation," there apparently is something radically wrong with the forestry profession or with the "exhortation and protest," and an internal examination to locate the difficulty seems in order. If the forestry profession wishes to accept the premises laid down by the authors of the letter as facts, the die is cast. If on the other hand foresters wish to approach the problem with unbiased minds and without preconceived ideas, I am willing to throw into the discussion a few thoughts for consideration.

To begin with, few professional foresters agree on the requirements of a fundamental forest policy. That has been amply demonstrated recently. As the first step, therefore, I would suggest that the profession find out what it does agree upon as a foundation upon which to build. Nothing should be taken for granted. It must be proven unless foresters wish to regard themselves as preachers of a prescribed gospel rather than as forest practitioners.

Second, why not remove the mystery and complexities surrounding the subject of forestry? It is simple if we leave out the fine theories. All that is necessary at this time is to determine timber requirements necessary to adequately meet our present and future needs. That requires first a study of present needs, second, a study of present supplies, third, a study of future needs, fourth, a study of how current requirements are being provided for at the present time, and fifth, what is necessary to do, if anything, to balance the predicted or assumed future requirements against supplies. During the relatively short life of the profession much emphasis has been placed upon the last step without due regard to those intervening.

Present needs for forest products, particularly lumber, are apparently being adequately cared for by a lumber industry operating at approximately 60 per cent capacity. Overnight, almost, the other 40 per cent can be brought into production without strain. Our full mill capacity is capable of turning out more lumber than has ever been required in any year to date. I realize of course that such a condition would be undesirable.

Increased production would undoubtedly result in lower lumber prices, but lower lumber prices can hardly be imagined that will long keep the industry solvent. The latest figures available to me (October, 1928), show that the wholesale lumber-buying power of a dollar in that month was 109.1 cents worth of lumber as against 100 cents for 1926, the base. (October, 1928, prices were much higher relatively than Febru-

ary, 1930.) Ten years ago, in 1920, the relative value was but 60.5 cents as compared to 1926.

Knowledge of present supplies requires an inventory of existing forest resources which has just been started by the United States Forest Service. When the results are available we can squarely face the situation and not until then. Present forest supply figures are largely the results of guess work.

The study of future lumber requirements is exceedingly complex. About all the evidence we have to go on now is that lumber production in general is declining, that there is a decline in industrial uses of wood, and that more markets for wood seem ready to fall. These are facts, distasteful to the lumber industry, and fraught with danger to profitable private forestry, but nevertheless indicating a trend in lumber consumption that cannot be disregarded. A tremendous effort must be expended on an analysis of why present consumption is dropping as an indication of future consumption before we can measure future requirements with any degree of assurance. Nonchalantly dismissing the whole matter, as is frequently done, with the statement that "large quantities of forest products will *always* be needed" does not by any means answer the question. Into this investigation will enter the matter of substitute materials, evolution of industries, and evolution in the form in which wood substance can be most advantageously used. Nobody knows the answer now and even an intelligent guess is impossible. How then can the forestry profession be expected to develop a national forest policy having to do with future situations that, in light of present knowledge, are wholly unknown?

The above is only from the angle of lumber and wood-products use. It has left out of consideration all other forest values such as cover for watershed protection, recreation, etc., the conservationist having so far directed his attention principally toward the lumber industry as devastator of a resource needed for the building of houses, raw material for industrial fabrication, and the like. Only recently has he begun to waver on the soundness of his doctrine and to place more and more emphasis on the necessity for a *forest* cover to control streamflow. On this latter issue, I think a substantial majority of the profession will gladly follow providing he closely defines "*forest*" cover to mean "*any*" cover which will bring about the desired results at lowest cost. A great deal of misunderstanding and confusion has resulted from the loose linking of "timber famine" and "watershed protection," and endless discussion has ensued in which it was not clear just what was being talked about. There is no necessity for confusion. They are distinct and each presents an issue which might conceivably be related to the other but not necessarily so. But here again we make claims without facts—do we know what kind of a cover is the most economical for watershed protection?

Watershed protection is a great national issue, an opinion that is shared by foresters and engineers generally. What should the nation do about it? First, study the watersheds of the various streams and rivers to find out (1) which ones need protection; (2) the character and size of areas involved; (3) what is the type and condition of cover, if any, on the areas; (4) what type of cover is best adapted to the varying topography and soil conditions, and can be put there at the lowest possible cost. This is a tre-

mendous task in itself, but not one primarily of interest to the forestry profession, except as it relates to trees if trees prove to be the proper cover material. The engineering features involved affect navigation, flood control, irrigation, domestic water supplies, the dissipation of agricultural soils, and other things of import. It is particularly a national problem because, as a rule, streams are interstate arteries and what happens in one state is often dependent upon what is done in others.

It is therefore apparent that protecting watersheds and raising trees for lumber are in no sense synonymous. If a forester wishes to argue the necessity for raising trees to avert a "timber famine" he should refrain from dragging in watershed protection to strengthen his argument. On the other hand, in discussing watershed protection it is not necessary to include forests because the best protective covering may be, and frequently will be, something besides trees.

The thinking of foresters to date has largely been directed toward ways and means for continuing adequate supplies of timber to produce *lumber* as that term is now defined, on the assumption that lumber is going to be increasingly important to the welfare of the nation. Unfortunately the steady decrease in total *and* per capita consumption of lumber has upset that premise. Industrial revolution is apparently working in the lumber industry just as it is in other industries, and recognition of the trend now may avert trouble later.

Lumber is by no means the sole product from forest trees. Recently there has appeared a new magazine entitled "Cellulose" devoted exclusively to a product which comprises the larger part of wood substance. Cellulose opens a wide vista of forest conversion. Its manifold present uses are but the beginnings of its possibilities. Although it is probable that high-grade lumber will always be wanted so long as it is available at a reasonable cost, it is not at all certain that raising it for future markets is sound policy.

In this connection I call attention to certain conclusions reached by a group of qualified men with reference to the future of forests and forest products and presented in the November, 1929, issue of the JOURNAL OF FORESTRY. I predict that it is but a relatively short time from the present practice to the time when boards, sash, frames, moldings, and in fact any desired finishing or factory shape will for the most part be pressed out of pulp and in the process will be rendered practically waterproof, decay-proof, and fireproof. This is largely a problem of cellulose chemistry, and mechanics.

If the above conclusions are sound, the forest problem is greatly simplified. In terms of cellulose, the supply of raw material in the forest is immediately trebled. If present forests are sufficient only to supply the lumber needs of the nation for 100 years, if converted into cellulose the supply becomes 300 years or more and the door is opened to competition from corn stalks, hay, or in fact all plant growth.

Through industrial evolution the "timber famine" fades into the background as the foundation for a great ideal and the forestry profession takes its place as a coöperator with other professions in working out the economics of the situation in order that its future usefulness may be unimpaired.

DEFEATISM OR OPTIMISM IN FORESTRY?

By NELSON C. BROWN

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SINCE the World War there has been considerable vogue in "debunking" tenets and theories that were formerly held in high regard. An heretical attitude toward some of our generally accepted policies and traditions has become widespread. Such was a natural reaction to the extreme spiritualism which had its birth in war propaganda. This trend toward realism has been in the main healthy but in many instances the pendulum has swung too far in the direction of a destructionist policy. Iconoclasm is abroad.

Forestry has not escaped. Perhaps it is an attempt at truth seeking—a casting off of traditional theories. However, in many phases of the profession there have been rumblings of discontent, doubt, and even the intrusion of cynicism. This attitude of mind has produced a widespread lack of courage and vision. I do not wish to appear to be favoring unduly that blind faith which has characterized so many new developments, and yet it seems to me that within recent years complaints that there are too many foresters, too many good schools training professional foresters, too many forestry graduates have been unhealthily frequent. Requested appropriations, protection programs, and planting plans appear to be so large that some foresters have stood aghast at their magnitude. Some of these men appear to be more concerned with the difficulties ahead, the hurdles to be jumped, the unforeseen troubles to be overcome than they are with how they shall plan for present emergencies and consummate constructive programs, some of which are bound to be milestones along the pathway of progress.

Some have expressed fear that there will be too great a wood supply in the future. They seem to lack a vision of the vast recreational uses of forests in the years to come, and of their influence in regulation of climate and waterflow and in many other phases of our future social and economic complex.

Timber is today sold under extreme competitive conditions. Many of our utilization problems remain unsolved. But with the growth of our population, the development of new uses for wood, and the increasing world demand for wood products, it seems likely that we shall need all the timber that can be grown on our forest areas not used for park, recreational, and protective purposes.

Forestry is still young but its youth has given to it a vigor and a mutability which the older professions no longer possess. Tremendous strides have been made during the past decade and a new concept of forestry has arisen. Its many opportunities and responsibilities have been greatly enlarged, as shown by the fact that today the proper seasoning, preserving, and even merchandizing of forest

products are recognized to be as vital as the growing of the crop.

Just as we had several attempts in the medieval ages on the part of ardent supporters of the Cross as against the Crescent, so now we need such a crusade in forestry, a real re-awakening of zeal, a re-inventory of objectives, a stirring of the soul of forestry; just such a recrudescence of faith, optimism, and foresight as inspired our leaders during the first decade of this century.

Are present foresters disturbed about their positions, concerned about competition, alarmed about their future? Is it true that they have discouraged young men from going into the profession? Have they adopted a cynical, anemic, attitude toward their work, opportunities for public service, and the general future of the profession? After all, what profession contributes more to the happiness, prosperity, and welfare of the country than our own? In what profession can one secure more pleasure and real sense of satisfaction than in forestry?

All public and professional movements revolve about the men who shape their destinies. No matter how high the ideals, standards, and ambitions, the achievements and accomplishments of any effort can be no greater than the vision of those who guide them toward their goals. Have we reached a "*laissez-faire*" attitude on our forestry ideals and standards? If we have, we need men of greater ability and capacity and those who will encourage a higher type to enter the profession.

Leaders in the legal, medical, engineering, and other professions tell us the supply of new men entering those fields is fairly adequate but that they do need recruits of greater ability, leadership, and vision.

The same is true in forestry. From the larger numbers now entering the profession we should develop a better personnel in the ranks. Good men often develop their own jobs. Foresters have generally been poor salesmen, both for themselves and for the cause of forestry. There is too much division of thought, lack of unanimity of purpose, quibbling over details, rather than constructive ideas and programs and policies which point a century, yes centuries ahead. Where would the foresters of the earlier years be today if they had dallied in a state of confused hesitancy about what the future years held in store for them and their profession? They carried on in a spirit of faith and optimism. They made their future, and had they not they would long since have been discouraged and dropped by the wayside. They held to their faith and their hopes have been rewarded by a fulfillment of their ideals even beyond their expectations.

We are now standing on the threshold of finer, bigger, and better things in forestry. Our Federal Forest Service is still sadly handicapped by lack of funds. Few states have programs and policies adequate to meet their requirements. Better and more attractive positions will become available. There are men who will fill many of these places but are they men of sufficient background, experience, and ability to measure up to their responsibilities? The crying need of many of our organizations is for a stronger personnel both of the "thinker" and the "doer" type.

The future of forestry may be in danger, but not because of a lack of opportunity. Too many foresters have indicated that it would be wiser not to take part in legislative affairs for fear of

later retraction. Fear of mistakes rather than courage and vision to go ahead appears to be their guiding motive. Alarmists and defeatists have met with entirely too much sympathy and encouragement; cynicism to some degree has replaced the idealism of yesterday.

It is well to give some consideration to the discouraging as well as the encouraging angles of our various problems, but America would never have been discovered, the World War never won, many modern inventions never adopted if we saw only the black clouds on the horizon, the discouragements, the pitfalls, the insurmountable hurdles to be overcome. We need the faith which inspired our forefathers, we need the pioneering spirit, and, if you please, the daring and courage which drove Byrd and Lindbergh toward their goals, the vision and aggressive enthusiasm of Pinchot, Pack, and Roosevelt, which gave reality to their dreams.

INFLUENCE OF FOREST LITTER ON RUN-OFF, PERCOLATION, AND EROSION

By W. C. LOWDERMILK

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THE object of the studies described in this paper was to determine:

1. The factors which influence the division of rainfall into surficial run-off and percolated water.

2. The effects of surficial run-off on soil erosion under certain conditions.

The work is a continuation and elaboration of certain studies conducted by the writer in northern China from 1924 to 1926, and forms a part of the program of the California Forest Experiment Station. The results will later be presented in more detail.

Devil Canyon Plots

Two pairs of surficial run-off plots, with an area of 1,000 square feet per plot, were installed in 1927 in Devil Canyon, San Bernardino National Forest, in southern California to measure the relative effects on the absorption of rain by a mountain soil covered with chaparral and one burned clean. In each case an inset border prevented the incursion of surficial run-off from outside the plot and precluded the escape of surficial run-off from the plot itself except through the aperture which led to measuring devices. Sediment traps between these and the plots made it possible to weigh accurately the eroded material. (Plate 1.)

During the season of 1927-1928, which had few run-off producing storms, the chaparral vegetation with its litter reduced both surficial run-off and erosion. Thus, the total run-off from the chaparral-covered plots was 1.2 cubic feet as against 4.4 cubic feet from the burned plots—a ratio of 1 to 3.7. Erosion from the chaparral plots amounted to 15.7 pounds of material as against 284.4 pounds from the burned plots—a ratio of 1 to 18.1.

The influence of the chaparral cover and litter on surficial run-off resulting from high intensities of rain is even more striking. Thus, during the 4.34-inch storm of April 2-3, 1928, when the maximum rainfall reached a rate of 0.133 inches per 5 minutes, the 5-minute rate of run-off from the chaparral plots was 0.02 cubic feet as against 1.33 cubic feet from the burned plots—a ratio of 1 to 66.5. These installations served to check the results of the studies in China, which had indicated a hitherto unmeasured rôle of forest litter (5, 6).

Berkeley Experiments

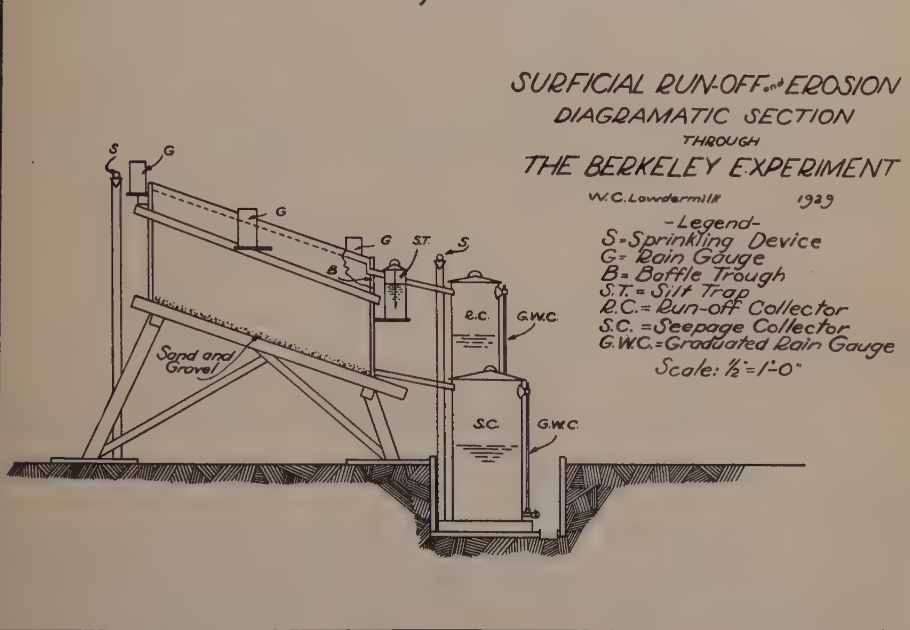
Studies of run-off from plots in place were supplemented by an intensive series of experiments at Berkeley, California, to determine more definitely the relation of litter to surficial run-off. In order to isolate this factor as completely as possible it was considered necessary to eliminate as much as possible sub-surface differences in soils resulting from channels caused by decayed roots and by

worm and animal burrows. Because of the greater importance of having the soils used in the experiment uniform than undisturbed, it was decided to take them up in shallow layers and then repack them by layers in their original order and approximately to their original volume.

This procedure was intended to render all conditions as nearly uniform as possible except at the surface of the soils. Differences in run-off or erosion in soil samples otherwise identical could then be attributed solely to the litter.

The soils were repacked in rectangular tanks of 18-gage galvanized iron encased in reinforced wooden frames. The tanks had horizontal dimensions of 2 x 5 feet and were so built as to provide for a soil depth of 2.5 feet and a surface slope of the soil of 30 per cent. (Plate 2 and Figure 1.) The development of percolation channels between the edge of the tank and the soil was prevented by two sets of narrow flanges, one 4 inches and the second 16 inches from the soil surface. The surficial run-off was caught by a baffle trough at the lower end of the tank, was conducted from here into the sediment trap in which suspended soil particles were separated from the rising current, and thence into the run-off collector tank. The latter was equipped with a glass gage graduated in inches and tenths to permit the direct reading of water heights with a mirror.

Figure 1.



Percolated water was collected in a layer of gravel and sand on the bottom of the tank and was conducted thence directly into the percolation tank, which had provision for measurement of water height similar to that of the run-off tank.

PLATE 1.—A detailed view of the instrumentation to measure rain intensities and rates of surficial run-off from chaparral-covered plots; burned plots are in the background. Baffle troughs at the end of the plots conduct the surficial run-off into pipes through a sediment trap and thence into the tipping bucket instrument which automatically records the rate of run-off. Devil Canyon, San Bernardino National Forest, Calif.

PLATE 2.—A general view of the installation to isolate and measure the influence of forest litter and duff on the surficial run-off from natural and artificial rain and the resultant effects in comparative erosion. Berkeley, Calif.

Provision was made for the rapid removal of percolated water in order to avoid possible interference from a rising water table. This made it possible to study the rôle of forest litter without the complications present on long slopes under natural conditions where a rising water table occasioned by heavy rains may sometimes play a decisive part in the effective infiltration of rain.

Provision was made to supply artificial rain by means of two horizontal 1-inch pipes fitted with special Skinner overhead sprinkling nozzles (No. 2). These nozzles were spaced at 2-foot intervals on each pipe and were so placed as to stagger the jets one foot apart. Provision was made to adjust the angle of the line of jets to varying wind velocities from east and west; adjustment for north and south winds required the sliding of the nozzle pipes either to north or south. Berkeley hydrant water was used under a pressure of approximately 60 pounds per square inch.

This installation made it possible:

1. To simulate rain in various amounts and at various intervals.
2. To measure surficial run-off.
3. To separate and measure material eroded by surficial run-off.
4. To measure percolated water.

Three widely separated soil series were selected for sampling: (1) Aiken, collected near Placerville, California; (2) unmapped Holland, collected 30 miles east of Sonora; and (3) Altamont, collected from the Berkeley Hills. The samples represented typical soil profiles covered with characteristic vegetation and were selected largely because of differences in the rate of percolation of water through them. They were collected and repacked in the experimental tanks by 1 to 4-inch layers in natural order as uniformly as possible. That substantial uniformity was obtained is shown by the results with the two pairs of supposedly identical tanks in the Altamont series which showed satisfactory agreement.

After the soils had been packed in the tanks, forest litter which had covered the respective soils in nature was placed on the surfaces. The soils were then permitted to settle during the rainy period from November, 1927, to March 8, 1928, when the experiment was begun. The natural layers of forest litter averaged approximately 2 inches thick.

The litter on the odd-numbered tanks was burned off clean with a Hauck torch before the application of artificial rain. Except for this, as far as could be foreseen, conditions were uniform within each pair of tanks. Since the experiment was designed to study only the influence of forest litter, apart from other factors, on the division of rain into surficial run-off and percolated water, the results are not directly applicable to percolation rates for a watershed.

The tanks were numbered as follows:

Tank number	Soil	Surface condition
I	Aiken sample from Placerville	Burned
II		Unburned
III	Holland sample from Stanislaus N. F.	Burned
IV		Unburned
V	Altamont sample from Strawberry Canyon, Berkeley Hills	Burned
VI		Unburned
VII		Burned
VIII		Unburned

Artificial rain was applied in series of ten rains of equal duration according to the schedule shown in Table 1. Natural rain also occurred on the dates indicated in this table. A period of one or two

days after natural rain was allowed for its seepage fraction to leave the tanks.

Both natural and artificial rain was measured in nine rain gages located systematically over the installation. These gages were checked for accuracy by calibration. No difficulty was encountered in the measurements of natural rain, which may be assumed to have fallen at uniform depths over all the tanks. Gusty and changeable winds on some days caused irregular depths of artificial rain over the tanks. The wind often changed between reading intervals of two hours and required a new adjustment of the nozzle pipe manifold. It is also possible that the individual jets, which were shot 15 to 20 feet into the air, did not entirely lose their identity, although the application was uniform as far as could be determined by observation.

In order to determine the depth of artificial rain, blue print plans of the tank installation were made to exact scale to show the projection surface of each tank and the location of each gage (Figure 2). The rainfall was determined separately for each run by recording the catch of each gage and drawing isohyetal lines through calculated interval points on the triangulation lines between the gage installations. The isohyetal interval was placed at 0.2 inch. The area of each isohyetal zone was planimetered and the total average depth of rain for each tank determined on an area basis. In subsequent experiments it will prove advisable to measure the amounts of artificial rain by rain troughs on each side of the tanks. These will integrate the total fall with greater accuracy and certainly with less calculation than a series of circular rain gages.

Table 1

SCHEDULE OF RUNS OF ARTIFICIAL RAIN ON SURFICIAL RUN-OFF SEEPAGE TANKS, 1928

Series	Duration of each run	No. of runs	Dates of runs	Approx. total rain in inches
A	Irregular (trial runs)	2	March 8–10	7.0
B	1 hour	10	March 14–26 (Rain, March 22–23)	15.0
C	2 hours	10	March 8–April 13 (Rain, Apr. 1–3, 14–18)	26.0
D	4 hours	10	April 20–May 6	44.0
E	8 hours	10	May 7–May 30	78.0
F	½ hour	10	June 5–June 25	7.5
G	1½ hours	10	July 12–Aug. 6	21.0
				198.5
Natural rain				
			March	3.60
			April	1.71
			May	0.37
				5.68

Comparative Surficial Run-off

The surficial run-off following artificial rain is shown in detail in Tables 2-5. In addition, graphs have been prepared for each soil and each series of artificial rain showing the cumulative

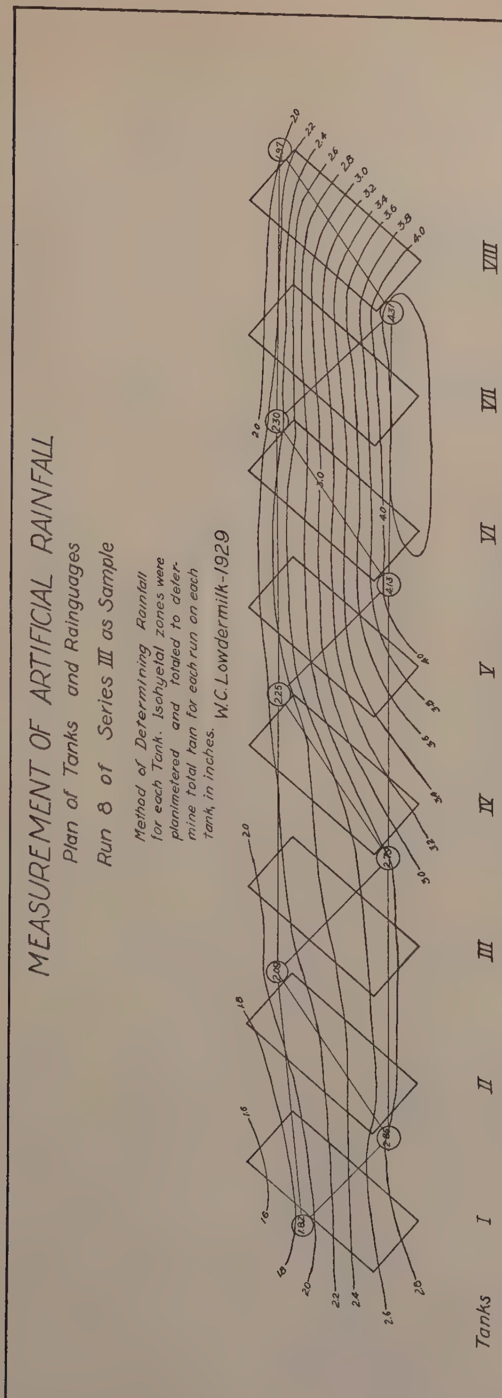

MEASUREMENT OF ARTIFICIAL RAINFALL
Plan of Tanks and Rainguages
Run 8 of Series III as Sample
Method of Determining Rainfall for each Tank. Isohyetal zones were planimetered and totaled to determine total rain for each run on each tank, in inches.
W.C. Lowdermilk-1929
Tanks
I
II
III
IV
V
VI
VII
VIII

Figure 2.

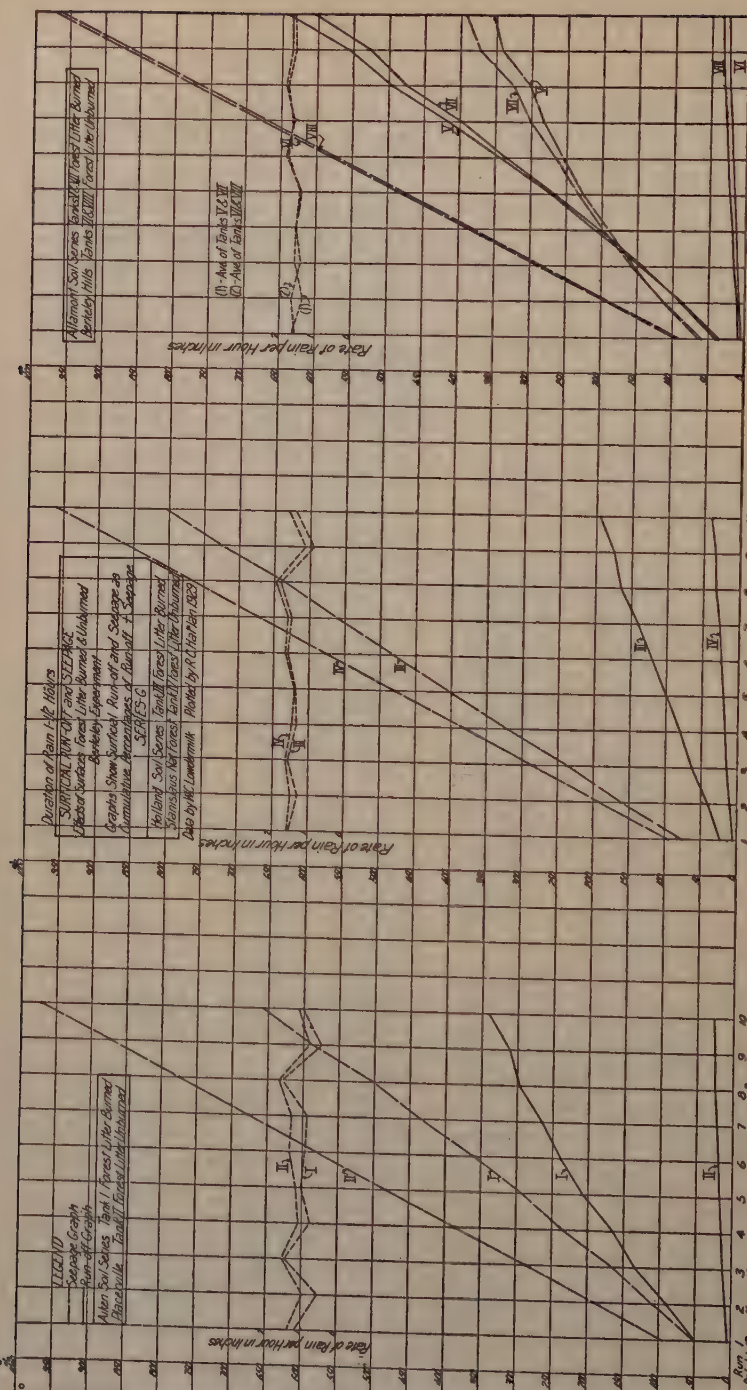


FIG. 3.—Artificial rainfall, cumulative surficial run-off, and cumulative seepage, Series G, Berkeley experiment.

TABLE 2

SUMMARY OF ARTIFICIAL RAIN AND COMPARATIVE SURFICIAL RUN-OFF FOR AIKEN SOIL SERIES, TANKS I AND II

Tanks		Series						
		A[a]	F	B	G	C	D	E
		Depth of Rain and Run-off in Inches						
I	Rain	5.68	6.56	12.05	14.28	15.05	39.87	52.01
	Run-off	.17	2.02	1.73	3.40	4.41	13.13	18.95
II	Rain	5.68	7.13	14.69	18.14	19.18	45.48	67.07
	Run-off	0.07	0.07	0.48	0.49	0.59	1.80	3.09
		Percentages of Run-off						
I		3.0	30.8	14.3	23.8	27.4	32.9	36.2
II		1.2	0.9	3.2	2.7	3.0	3.9	4.6

[a] Natural rain totaled from March 8 through April and May.

TABLE 3

SUMMARY OF ARTIFICIAL RAIN AND COMPARATIVE SURFICIAL RUN-OFF FOR HOLLAND SOIL SERIES, TANKS III AND IV

Tanks		Series						
		A[a]	F	B	G	C	D	E
		Depth of Rain and Run-off in Inches						
III	Rain	5.68	8.19	15.27	20.77	21.13	44.03	75.24
	Run-off	0.11	3.37	9.12	4.05	8.05	12.38	17.75
IV	Rain	5.68	8.36	15.95	22.47	22.59	46.24	80.00
	Run-off	0.08	1.34	3.61	0.94	2.70	6.15	8.53
		Percentages of Run-off						
III	Run-off	1.9	41.1	59.7	19.5	38.0	28.1	23.5
IV	Run-off	1.4	16.0	22.6	4.1	11.9	13.3	10.6

[a] Natural rain totaled from March 8 through April and May.

TABLE 4

SUMMARY OF ARTIFICIAL RAIN AND COMPARATIVE SURFICIAL RUN-OFF FOR ALTAMONT SOIL SERIES, TANKS V AND VI

Tanks		Series						
		A[a]	F	B	G	C	D	E
		Depth of Rain and Run-off in Inches						
V	Rain	5.68	8.12	17.23	23.49	23.01	45.61	83.91
	Run-off	0.95	2.25	7.17	14.44	14.44	19.33	47.70
VI	Rain	5.68	8.43	17.92	24.96	23.44	44.84	88.89
	Run-off	0.06	0.09	0.31	0.63	0.88	2.38	3.12
		Percentages of Run-off						
V	Run-off	16.7	27.7	41.6	61.5	62.7	42.4	56.8
VI	Run-off	1.0	1.0	1.7	2.5	3.7	5.3	3.5

[a] Natural rain totaled from March 8 through April and May.

TABLE 5

SUMMARY OF ARTIFICIAL RAIN AND COMPARATIVE SURFICIAL RUN-OFF FOR ALTAMONT SOIL SERIES, TANKS VII AND VIII (DUPLICATES OF V AND VI)

Tanks		Series						
		A[a]	F	B	G	C	D	E
		Depth of Rain and Run-off in Inches						
VII	Rain	5.68	8.25	17.62	24.55	22.46	42.77	88.68
	Run-off	1.12	2.62	7.67	14.90	14.80	17.42	46.17
VIII	Rain	5.68	7.83	12.82	22.93	14.52	36.68	82.70
	Run-off	0.15	0.11	0.53	0.69	1.07	1.91	3.64
		Percentages of Run-off						
VII	Run-off	19.7	31.7	43.5	60.7	65.8	40.7	52.0
VIII	Run-off	2.6	1.4	4.1	3.0	7.3	5.2	4.4

[a] Natural rain totaled from March 8 through April and May.

surficial run-off and the percolated water as a percentage of their sum together with the average rate of artificial rain per hour. A typical sample of these graphs is shown in Figure 3. Under calm conditions the rate of rainfall was slightly more than 2 inches per hour, with lesser rates during gusty or fairly strong winds. The experiment was not run during heavy winds. The average rate was slightly more than 1 inch per hour.

The cumulative graphs were used because they constitute one of the most sensitive methods for indicating a trend of a series of phenomena. The more uniform the trend the more nearly the graph approaches a straight line. Its angle with the base line may be taken as an index of the trend.

In the present experiments the surficial run-off from the burned surface was greater in every instance than from the litter-covered surface. The differences in the Holland soil, a fine sandy loam, were on the order of 3:1; in the Aiken soil, a sandy clay loam, on the order of 9:1; and in the Altamont soil, a clay loam, on the order of 16.5:1. The litter was thus more effective on the fine-texured soils than on the coarser-textured soils.

Contrary to expectation the coarser-textured Holland soil in a bare condition was not the most absorbent of rain. With this the average percentage of surficial run-off was 35, while with the Aiken soil it was 27, and with the Altamont 49. Under the forest litter, however, the absorptive capacities of the soils changed remarkably. Surficial run-off from both the Aiken and Altamont soils approximated 3 per cent, as against 13 per cent with the Holland soil—a ratio of 1:4. The forest litter, therefore, played a much larger rôle in the absorption of rain on the fine-textured soils. This order of influence coincides with the influence on erosion by the surficial run-off.

The original experimental runs were completed in August, 1928. The installation was maintained throughout the following year with no additional treatment except to prevent the development of vegetation, and repeat runs were made in July and August of 1929 to discover if further settling or other influences might change the relationships discovered in the first series of experimental runs. Table 6 shows a comparison between runs of the original series of similar duration and intensities with the

repeat runs. Series A, including the intermittent natural rains, is not included in these comparisons.

The results of the repeat runs confirm the findings of the original experiment. After a year's time the litter appears to be more effective in favoring penetration of rain into the soil. The only explanation which has been found is the activity of earthworms, whose castings are evident in the litter-covered tanks. The development of macro-structural features in a soil profile which were noted in the sampling can reasonably be assumed to increase its capacity for penetration over artificially packed soils, a condition represented by the tanks during the first experimental runs.

The most significant feature of the experiments is that the forest litter continued to function for all durations of rain in approximately the same order. Run-off graphs for the burned and litter-covered tanks in the same soil series maintain uniform angle relationships except when the rainfall differs widely for the two tanks. Indeed, the percentage of surficial run-off from the Altamont and Holland soils was lower in the 8-hour application than in the 4 or 2-hour applications. It is difficult to explain this reversal of expectation, which only accentuates the finding that the litter when saturated continued to maintain a high percolation capacity in the soil.

Comparative Erosion

Eroded material caught in the sediment traps is shown in Table 7. Surficial run-off from burned surfaces was muddy while that from litter-covered surfaces was clear. Such material from the latter as was collected in the sediment traps was chiefly organic particles of the litter as determined by ignition tests.

The differences between the burned and litter-covered soils in amounts of eroded material are far greater than the differences in run-off. Erosion thus proved to be a more sensitive index in the change of surface condition than surficial run-off. The rate of erosion, however, did not increase uniformly with the increase in total surficial run-off. This effect was most noticeable on the Aiken soil, where a conspicuous "erosion pavement" developed.

Differences in eroded material from the different soils are notable. The fine-textured soils yielded the greatest amount of sediment. For example, the sediment in Series C from the bare Altamont soil was 11 to 16 times that from the Aiken, and 4 to 6 times that from the Holland.

Table 6

SURFICIAL RUN-OFF IN REPEAT RUNS AND FIRST EXPERIMENTAL RUNS, IN PERCENTAGE OF SURFICIAL RUN-OFF PLUS SEEPAGE

Soil series	Aiken		Holland		Altamont			
Tanks	I	II	III	IV	V	VI	VII	VIII
First Runs	30.7	3.5	31.2	13.0	48.6	3.6	47.1	4.7
Repeats	38.7	0.7	40.8	21.9	66.7	1.3	58.5	1.4

Rôle of Forest Litter

In these experiments the forest litter, independent of the forest, served to maintain the soils under them in a state of far greater absorptive capacity than the same soils which had been burned bare

of forest litter. This action, which has not hitherto been measured, continued far beyond the complete saturation of the litter.

Forest litter has generally been credited chiefly with a capacity to absorb water up to the saturation point, and various authors have expressed the view that when this point is reached the surficial run-off from forest soil will be at the same, or almost the same, rate as from a bare surface (1, 2, 8, 9). This view overlooks the macro-structural characters of the soil which may be related to the presence of a mantle of vegetation during the course of soil development. Likewise, emphasis has been placed upon the forest rather than upon the soil mantle, which in the final analysis is the primary absorbent of rainfall. Vegetation, its litter, and the soil fauna which it supports have determined under given climatic conditions through long periods of time the characters which a soil profile possesses.

The capacity of forest litter to hold large quantities of rain has been most emphasized by former workers, and additional functions such as mechanical hindrance to surface flow have been recognized but not measured (3, 4, 5, 10, 11, 12). Accordingly, the litter samples in the present experiment were studied with reference to these factors.

TABLE 7

MATERIAL ERODED FROM TANK SURFACES BY SERIES OF APPLICATIONS OF ARTIFICIAL RAIN, AND WEIGHT RATIO OF SILT TO SURFICIAL RUN-OFF WATER. (ARRANGED ACCORDING TO CHRONOLOGICAL ORDER OF RUNS)

Item	Tanks I	II	III	IV	V	VI	VII	VIII
Series B. 10 Runs of 1 Hour Each								
Weight, grams	40.60	0.40	646.75	1.70	516.80	0.300	670.65	0.90
Ratio, %	0.10	0.035	0.30	0.02	0.31	0.041	0.37	0.07
Series C. 10 Runs of 2 Hours Each								
Weight, grams	89.65	0.35	235.60	0.59	1003.50	0.43	1472.93	3.61
Ratio, %	0.86	0.025	0.12	0.009	0.260	0.002	0.42	0.014
Series D. 10 Runs of 4 Hours Each								
Weight, grams	35.40	0.45	19.02	2.48	437.35	0.500	370.81	1.0
Ratio, %	0.001	0.0001	0.006	0.001	0.1	0.001	0.09	0.002
Series E. 10 Runs of 8 Hours Each								
Weight, grams	48.65	0.50	235.60	1.07	2253.7	0.30	1910.6	0.95
Ratio, %	0.01	0.0007	0.05	0.0005	0.200	0.0004	0.18	0.001
Series F. 10 Runs of One-Half Hour Each								
Weight, grams	18.60	0.05	234.02	2.00	275.80	0.60	295.10	0.42
Ratio, %	0.040	0.003	0.30	0.086	0.520	0.030	0.46	0.016
Series G. 10 Runs of 1½ Hours Each								
Weight, grams	38.15	2.00	28.10	0.950	1317.70	0.400	1241.20	0.47
Ratio, %	0.047	0.017	0.030	0.004	0.383	0.0027	0.353	0.0028

In determining the moisture-holding capacity tubes 4 inches in diameter and 36 inches long with fine screen bottoms were filled with litter, set in water for different lengths of time, and allowed to drain after each wetting. The water retained by the litter sample against gravity was determined three times successively with the results shown in Tables 8 and 9.

The litter was collected in two layers easily determinable in the field, namely the top and second layers. The top layer comprised all litter which showed no evidences of decay and represented the current fall of leaves. The second layer or duff comprised all partially decomposed material above the mineral soil surface. Both layers are designated in soil terminology as "A_0" of the profile. The top layers had at the end of the third determination water-holding capacities of from 200 to approximately 300 per cent of their laboratory dry weight, and the second layers of from 85 to approximately 250 per cent of their dry weight. On this basis where the top layer is 1/9 and the second layer 8/9 of the total litter, its average water-holding capacity is 180 per cent of its air-dry weight. The depth of rain water absorbed by the pine-fir forest litter was approximately 0.26 inches. The smaller samples of litter from the chaparral type of the Berkeley Hills when evenly distributed to a depth of 2.0 inches was estimated to absorb 0.6 inch.

TABLE 8

QUANTITY OF FOREST LITTER [a]

Locality	Forest type	Air-dry litter weight per 0.001 acre: Undecomposed layer Kgs.	Decomposing layer Kgs.	Total Kgs.	Metric tons per acre
Near Placerville, Aiken Series	Pine-fir-cedar	3.909	23.888	27.797	27.8
Stanislaus National Forest, near Strawberry	Pine-fir	1.902	25.677	27.579	27.6
Berkeley Hills	Oak-chaparral	(estimated on basis of square foot samples)			25.0

[a] The undecomposed layer represents the year's fall of litter. The decomposing layer represents a number of years' fall, depending on its rate of decomposition, which has not been determined.

TABLE 9

WATER-HOLDING CAPACITY OF FOREST LITTER SAMPLES, 1928, IN GRAMS AND PER CENT OF DRY WEIGHT

Sample number	Forest type	Layer	Air dry weight	Water retained after successive saturations: March 3 Grams	March 3 Per cent	March 7 Grams	March 7 Per cent	March 24 Grams	March 24 Per cent
1	Pine-fir	Top	689	947	137.4	1642	238.3	1439	208.8
2	Pine-fir	Top	579	827	143.0	1416	244.5	1178	203.4
3	Pine-fir	Second	2916	1930	66.2	2515	86.2	2454	84.1
4	Pine-fir	Second	2515	4469	177.7	5096	202.6	5015	199.4
5	Pine-fir-cedar	Top	543	1164	214.3	1832	337.3	1591	293.0
6	Pine-fir-cedar	Top	580	1268	218.6	1966	338.9	1724	297.2
7	Pine-fir-cedar	Second	1488	2941	197.6	3749	252.0	3676	247.0
8	Pine-fir-cedar	Second	1533	3133	204.3	3826	250.0	3725	243.6

The experimental runs with the large tanks of soil followed each other so closely that the litter was dry only at the surface at the beginning of succeeding applications. Since the trend of absorption maintains practically straight line relationships with run-off the absorption of the litter to saturation point could have played only a very small part in the differences in run-off from the contrasted surfaces.

Mechanical hindrance to flow by the litter doubtless is important. By delaying the surface flow and producing small hydrostatic heads this tends to increase percolation, particularly for small quantities of rain. Analysis of the data in the present experiments, however, indicates that mechanical hindrance to surface flow is not the most important factor in promoting percolation. Thus the percentage of surficial run-off from Tank II in Series B to E increased from 3.2 to 4.6 per cent of the rainfall, or about 44 per cent, while in Tank I the increase was from 14.3 to 36.2 per cent, or more than 253 per cent. In Tank IV there was an actual decrease in the run-off in percentage of rainfall from 22.6 in Series B to 10.6 per cent in Series E.

The evidence is not sufficient to indicate a direct relationship between surficial run-off and the colloidal clay surface of the soil. The percentage of the run-off from bare soils, however, exhibited the same trend as the colloidal clay fraction. This trend is reversed in the case of soil samples covered with forest litter. The finer the soil texture the more the forest litter may be expected to function in reducing the percentage of surficial run-off in cases where the percolation capacity of the soil is not exceeded. It is probable that with an increase of textural sizes, a point may be reached where forest litter will have no influence.

In order to test experimentally the effect of muddy water on the rate of percolation into bare soil under controlled conditions, four tubes 8 inches in diameter, numbered 10, 11, 12, and 13, were uniformly packed with Holland soil. (Figure 4.) By careful manipulation water was first applied at the drainage outlets and made to rise slowly through each soil column until the soil surface was covered with clear water. A sieve with 100 meshes to the inch was fitted into the top of the tube and the water level raised above the sieve, which was used to prevent the formation of currents over the soil as additional water was applied to the surface. These currents would pick up fine particles of soil in suspension and sort them in settling.

Once the soils had been saturated and covered with water they were kept so by a supply from the top. Automatic floats were installed to keep the head of clear water at a constant level. The percolated water was then caught in the bottom and measured, generally at one-hour intervals.

Clear water was run through the four tubes for parts of seven days to establish the percolating characteristic of each. Muddy water was then prepared by stirring samples of the same soil into water. In accordance with the well-known Stokes Law for the rate of fall of soil particles in a liquid, water was siphoned from the mixture so as to contain soil particles in diameters of .05 mm. and less. Only silt and clay fractions were contained in the muddy water, which was agitated by a paddle driven by an electric motor to prevent settling. Determinations for sediment showed 1.7 to 1.9 per cent by weight.

As soon as the muddy water was applied to tubes 10 and 11, the rate of percolation diminished until within 6 hours it had fallen to less than 1/10 of the rate for clear water. The percolated water remained clear. (Figure 5.)

Clear water was run through tubes 12 and 13 for another week. An accident with tube 13 caused a stir of the surface soil into suspension with an immedi-

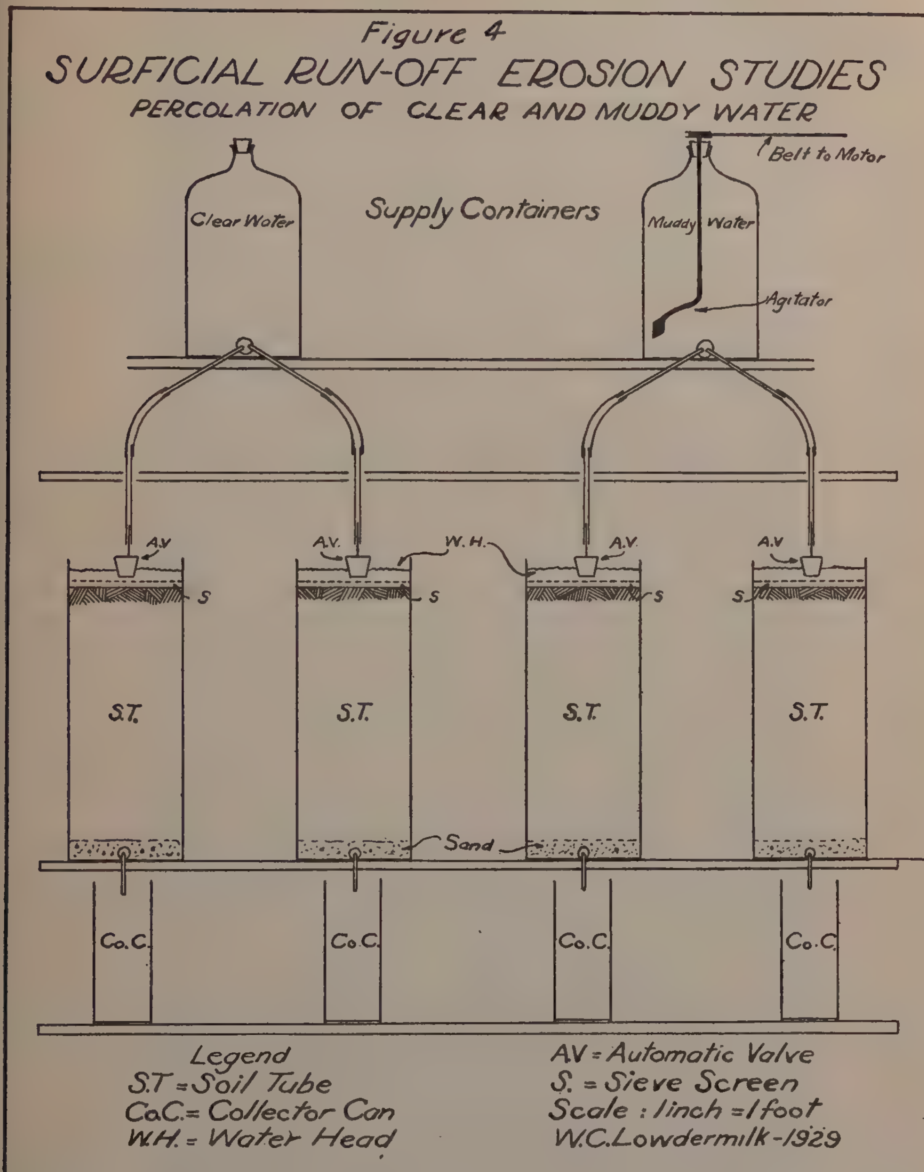


Figure 4
SURFICIAL RUN-OFF EROSION STUDIES
PERCOLATION OF CLEAR AND MUDDY WATER
Belt to Motor
Clear Water
Supply Containers
Muddy Water
Agitator
A.V
A.V.
W.H.
A.V
A.V
S
S
S
S
S.T.
S.T.
S.T.
S.T.
Sand
Co.C.
Co.C.
Co.C.
Co.C.
Legend
S.T = Soil Tube
CoC. = Collector Can
W.H. = Water Head
AV = Automatic Valve
S. = Sieve Screen
Scale : 1inch = 1foot
W.C.Lowdermilk-1929

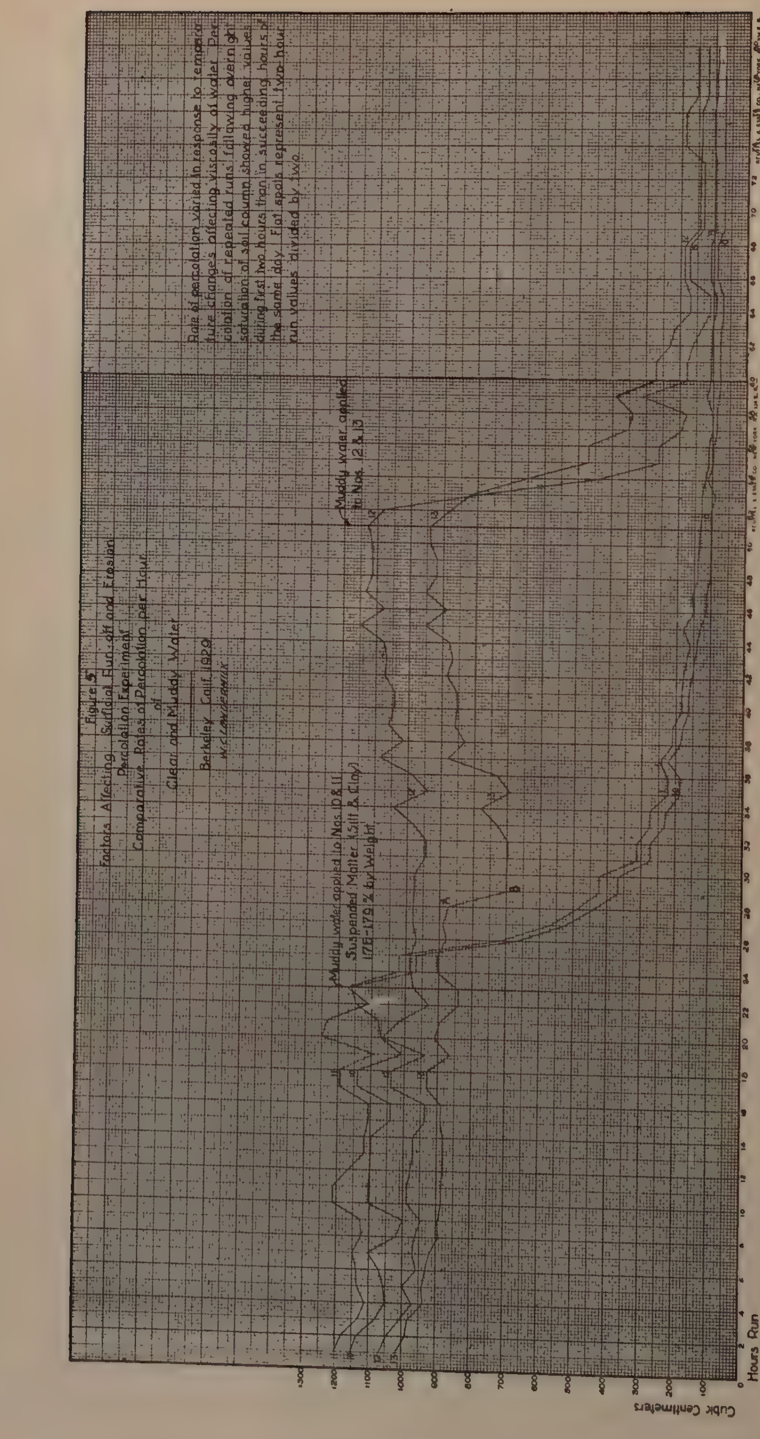


Figure 5
Factors Affecting Surficial Run-off and Erosion
Percolation Experiment
Comparative Rates of Percolation per Hour
of
Clear and Muddy Water
Berkeley Calif. 1929
W.C. LOWDERMILK
Muddy water applied to Nos. 10 & 11
Suspended Matter (Silt & Clay)
176-179 % by Weight
Muddy water applied to Nos. 12 & 13
Rate of percolation varied in response to temperature changes affecting viscosity of water. Percolation of repeated runs following overnight saturation of soil column showed higher values during first two hours than in succeeding hours of the same day. Flat spots represent two-hour run values divided by two.
Cubic Centimeters
Hours Run

ate response in reduced percolation. See A-B, Figure 5. Muddy water was finally applied to tubes 12 and 13 and clear water again to tubes 10 and 11. Immediately the rate of percolation diminished in tubes 12 and 13 in essentially the same way as it had previously done in tubes 10 and 11. Furthermore, the rate of percolation in tubes 10 and 11 did not change with the application of clear water following the application of muddy water. Evidently the fine-textured layer which had formed at the surface continued to determine the rate of percolation for the entire soil column.

This experiment demonstrated decisively that muddy water percolates through a sandy loam soil at only a fraction of the rate of clear water. Suspended particles were filtered out at the soil surface where they formed layers of fine-textured material which determined the rate of percolation quite independent of the percolation capacity of the soil column. The reduced rate of percolation is of sufficient magnitude to account for major differences in absorption such as were observed in the present experiments.

The formation of a fine-textured layer at the surface of a bare soil as a result of filtering suspended particles from percolating muddy water is, therefore, concluded to be the decisive condition which increases the surficial run-off from bare surfaces. This fact indicates that the most important function of forest litter is to maintain the natural characteristics of a soil profile by keeping the rain water clear—a function which has been generally overlooked, or if considered at all only with an inadequate conception of its significance. It seems clear that with an undisturbed mantle of vegetation the percolation capacity of the soil remains at a maximum even in extremely heavy and prolonged rains. The removal of percolated water from the soil is a matter of streamflow in waterways which is beyond the scope of this paper.

Normal and Accelerated Erosion

It is clear that the normal rate of erosion, including the responses to unusual meteorological phenomena, is inseparably related to the natural mantle of vegetation as it existed prior to disturbance from outside factors, such as man and his agencies. When, however, the mantle of vegetation is destroyed so as to expose the soil to the full force of processes of surface removal, against which it was formerly protected, we find erosion of a different order. This has been termed "accelerated erosion," in contrast to the norm established in response to the interplay of geologic factors, including climate and time.

Accelerated erosion reduces the depth of the soil profile on sloping lands and thereby reduces the capacity of the soil to absorb rain water. Further consideration of this phase of the subject belongs with an examination of the accumulation of water in stream channels.

The index of accelerated erosion is increased silt or suspended soil carried in the streams of run-off water. A marked increase in the sediment load of streams can usually be attributed to a more rapid erosion of the soil mantle of a drainage basin rather than to augmented corrasion and abrasion by streams. A sediment record of rivers is as important in a hydrographic record as the volume of streamflow, and is a more sensitive index of the state of the watershed than measured streamflow which is

dependent on a number of interacting factors.

Accelerated erosion, therefore, alters the processes of soil weathering. The A horizon is the first to go, and the sealing action resulting from the filtering-out at the surface of suspended particles tends to accelerate the surficial run-off with augmented capacities for erosion and transport. An unlooked-for element in the run-off erosion factor in the present experiment, particularly in the Aiken soil samples, was the development of "erosion pavement." Its formation is not unlike that of desert pavement, wherein the agency removing fine soil particles is unable to move larger particles. As the depth of removal of fine particles increases the larger fragments collect on the surface until a pavement of cobble is formed. This erosion pavement serves to check further removal of fine particles until the formation of gullies which undermine the pavement and hasten the process of soil removal.

Conclusions

1. Forest litter in these experiments greatly reduced surficial run-off, particularly in the finer textured soils; and this influence continued long after the litter was completely saturated.

2. Destruction of the litter and the consequent exposure of the soil greatly increased the amount of eroded material and reduced the absorption rate of the soil.

3. Suspended particles in run-off water from bare soils were filtered out at the surface and sealed the pores and seepage openings into the soil sufficiently to account primarily for the marked differences in rate of absorption between bare and litter-covered soils.

4. The capacity of forest litter to absorb rainfall is insignificant in comparison with its ability to maintain the maximum percolating capacity of soil profiles.

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SEED FLIGHT IN THE DOUGLAS FIR REGION

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A KNOWLEDGE of the distance to which tree seed is carried by the wind is important in silviculture where natural reproduction is sought from seed shed by banks of green timber or by single trees. In the heavy old-growth Douglas fir (*Pseudotsuga taxifolia*) forests of western Washington and Oregon, clear cutting with broadcast slash burning appears to be the only feasible method of forest management. Here Douglas fir and its associates reproduce readily from wind-blown seed, and it is important to know how far seed may be carried in order to provide for the natural reseeding of cut-over areas.

Prior to the beginning of this study in 1925 practically no work had been done in the study of wind dissemination of tree seeds, therefore the methods used and the results obtained may both be of interest to foresters. Two distinctly different methods of study were employed. The first consisted in placing seed traps at regular intervals from the edge of a bank of green timber and trapping the seed as it fell naturally; the second consisted in releasing winged seed from a box kite and from a pilot balloon over fields and making counts on the snow. The first method gave a measure of seed fall as it occurred in nature, including all heights at which it was produced and all weather conditions that occurred during the dissemination period, while the second showed the distribution of seed from known heights and in measured wind velocities.

Measurement of Natural Seed Fall by Seed Traps

Two areas were selected for the seed-trap method of study. The first was a small body of Douglas fir of the woodlot type. In this there had been irregular cutting for the past 40 years which resulted in light stocking and crowns that were longer than normal. The trees on this area were approximately 75 years old and 150 feet in height. The second area was typical of the virgin Douglas fir stands being logged in the region. These trees averaged 225 years old and 210 feet in height and had short, pointed crowns. The direct measure of seed fall at different distances was obtained by setting traps at 100-foot intervals from the timber edge and collecting the seed from them every two weeks during the dissemination period.

The seed traps consisted of 4-foot square trays with rodent-proof covers. The trays had sides of 1 by 4-inch boards and fly-screen bottoms. The covers were of ½-inch mesh screen held in a frame of 1 by 2-inch slats. Traps were set as nearly level as possible and just above the ground. The fine screen on the bottom permitted dust and moisture to pass through. Gusts of wind passing over a trap had a tendency to force some air down through the screen bottom, thus

tending to hold the seed rather than to slide it along and whirl it out of the traps, as might occur if the bottom were smooth and solid.

To test the efficiency of the trap for holding seed, one trap was placed in position and 100 winged seeds were dropped through the coarse screen cover. After being exposed to fall and winter weather for a period of 49 days, 96 seeds (or 96 per cent) were still in the trap.

The 4 by 4-foot traps when set in a line at 100-foot intervals represented 4 per cent of a 4-foot strip. Thus it may be seen that they constituted but a small sample of the entire receiving area, which may account for some of the irregularities shown in seed fall. Also it is very probable that on both areas some sound seed was carried a considerable distance beyond the point where the last was caught.

Cutting tests were made of all seed taken from the traps during the season and the figures given for seed-fall per acre are based on the number of *sound* seed caught.

Weather records at Portland, Oregon, within 35 miles of both areas, showed occasional winds of 30 miles an hour during the seed dissemination season, but these winds usually occurred in periods of wet weather when it is not likely that seeds were being released.

A record of seed fall from one light and one heavy crop was obtained from the woodlot stand. On this area many of the crowns extended half the length of the boles. Cones were produced on all parts of the crowns during the heavy seed year, but when the light crop occurred most of the cones were borne close to the top of the trees.

During the season of heavy crop, seed fell at the rate of 203,000 to the acre 100 feet from the edge of the timber. At 200 feet the fall was reduced to 40,600 seeds to the acre. From that point out the decrease was irregular, showing no seed at 700 feet and 8,700 to the acre at 900 feet. No sound seeds were found beyond 900 feet, but culls were found as far as 1100 feet.

When the light crop occurred on this area the fall at 100 feet from the timber was 26,100, and at 200 feet 29,000 seeds to the acre. From that point it dropped off to 2900 seeds at 500 feet and no sound seeds were caught farther out. A seed trap placed under the timber showed a fall of 75,000 seed to the acre, or approximately three times the fall that occurred at 100 and 200 feet from the edge of the timber.

A record of seed fall from the typical virgin Douglas fir stand was obtained for a light seed crop only. This gave a fall of 40,000 seeds to the acre at 100 feet from the timber edge. Beyond that point the fall was irregular, showing 14,500 seeds to the acre at 800 feet, but less at some of the intermediate points. No sound seeds were caught beyond 800 feet, but culls were found in the traps as far out as 2400 feet from the timber edge. As is indicated by the findings on the woodlot stand, it is certain that a heavy seed crop on this (virgin timber) area would have increased the fall both in distance and density, but a measure of this increase cannot be obtained until a heavy crop occurs.

Table 1 compares the results obtained on the two areas and brings out the interesting fact that from the 300-foot point to the end of flight the seed fall from the *light crop* on tall timber very

nearly equaled the seed fall from the *heavy crop* on short timber, but up to the 300-foot point the seed fall from the short timber was very much the heavier of the two. The seed fall from the *light crop* on the short timber was considerably less than the seed fall from the *light crop* on the tall timber at all points except at 200 feet. Thus it may be seen that the height of the tree and the length of the crown have a definite bearing on the distribution of seed.

TABLE 1

SEED FALL FROM DOUGLAS FIR AS SHOWN BY NUMBER OF SEEDS PER ACRE AT 100-FOOT INTERVALS FROM THE TIMBER

Woodlot type at Scappoose, Oregon, 150 feet high

Crop and year	Under timber	Feet from timber edge								
		100	200	300	400	500	600	700	800	900
Heavy crop, 1925..	No record	203,000	40,600	26,100	5,800	14,500	5,800	0	5,800	8,700
Light crop, 1926...	75,400	26,100	29,000	8,700	0	2,900	0	0	0	0
Virgin timber type at Wilark, Oregon, 210 feet high										
Light crop, 1926...	No record	40,600	17,400	17,400	5,800	5,800	0	2,900	14,500	0

DISSEMINATION OF SEED FROM BOX KITE AND PILOT BALLOON

This method of study was designed to give a measure of seed flight under known conditions and to serve as a check on the results obtained with the seed traps; also to get a comparison of the flight of Douglas fir with that of its associates. Tests were made of Douglas fir (*Pseudotsuga taxifolia*), western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), noble fir (*Abies nobilis*), western white pine (*Pinus monticola*), and western yellow pine (*Pinus ponderosa*). Twenty-five tests were made, mostly with Douglas fir since it is the principal tree of the region. For the sake of brevity representative tests of Douglas fir and only one each of the species are presented in Tables 2 and 3.

Seeds were released at elevations of from 100 to 200 feet to show the effect of tree heights on dissemination, and in wind velocities of from 23 to 2.2 miles an hour to show the effect of high and low winds.

Wind velocities at a point 6 feet above the ground were recorded while each test was being made. To determine the difference between the wind velocity at the ground and that aloft, a few simultaneous readings were taken. The wind velocity at tree heights was obtained by attaching an airmeter to the kite.

A minimum wind velocity of 5 miles an hour was required to raise the box kite and a wind of that velocity or stronger had a tendency to "blow down" the captive balloon. Therefore the kite was used for tests in the higher winds

and the balloon in the more gentle breezes. When the balloon was used the seed carton was attached about 2 feet below it, but when the kite was used it was found necessary to attach a drop cord to the kite and allow it to rise to steady air (about 200 feet), then attach the seed carton to the drop cord. The kite was then allowed to rise further until it had lifted the carton to the desired height.

Charges containing a known number of winged seeds were placed in the cardboard cartons and a hinged cover tied shut with a fine thread that could be broken by a jerk on a trip line. The individual charges varied in size from 1,000 to 100,000 seed, the number being controlled by the size of the seed and the lifting capacity of the balloon or the kite in different wind velocities. When the numbered marks on the tripping cord indicated that the desired height had been reached, a quick jerk on the cord would open the cover of the carton and release the seed in the air.

All tests were conducted over comparatively level snow fields. The tiny cloud of seed, as it traveled down the wind, was plainly visible during most of its flight and as it settled to the surface the pattern made by the seed on the snow clearly outlined the path of flight. It was a matter of surprise to find that seed from a single charge released in a body fell in a long strip about 35 feet wide. This strip curved gently first to one side of the general wind direction and then to the other.

Immediately after each release the entire path of seed fall was gridironed, counting all seeds on a 4-foot cross strip at 100 or 200-foot intervals. The count on the 4-foot strip was made by placing a 4 by 8-foot frame on the snow and counting the seed inside, then shifting the frame and repeating the operation until the strip had been covered. There was surprisingly little drift of seed on the surface of the snow during the time required to make the seed counts.

Accuracy of sampling in both kite and balloon tests is shown by comparing the per cent of the area sampled with the per cent of the seed charge that was recovered. In the kite tests at wind velocities of five miles an hour and higher, 1.9 per cent of the total number of seed was recovered on 2 per cent of the area, while in the balloon tests at the lower wind velocities 3.8 per cent of the total number of seed was recovered on 4 per cent of the area.

The distribution of sound seed on the ground was determined by making cutting tests of samples picked up at regular intervals from the point of release. The per cent of sound seed was found to be about normal for the lot at the place where the heaviest fall occurred; between that place and the point of release the per cent of sound seed was above normal, and beyond that place the per cent of sound seed was below normal for the lot.

The importance of the height at which seed is released is shown by the results of two tests of Douglas fir (Figure 1) made in a wind velocity of 7 miles an hour. In one test seed was released at a height of 100 feet, and in the other of 200 feet. From the charge released at the lower elevation seed started to fall within 100 feet horizontal distance, fell in greatest density at 400 feet, and was all down before the 800-foot point was reached. The seeds from the charge released at 200 feet started to fall within 100 feet, attained maximum density at 1,000 feet, and tapered off to an extreme

limit of flight at 2,400 feet from the point of release. Thus it is seen that the height of the tree may have a definite bearing on the distance to which its seed is carried by the wind. Doubling the height of release more than doubles the distance of dissemination. This relative increase is probably the result of greater wind velocity at higher elevations. A few simultaneous readings indicate that the wind velocity at an elevation of 150 feet is approximately double that at the surface.

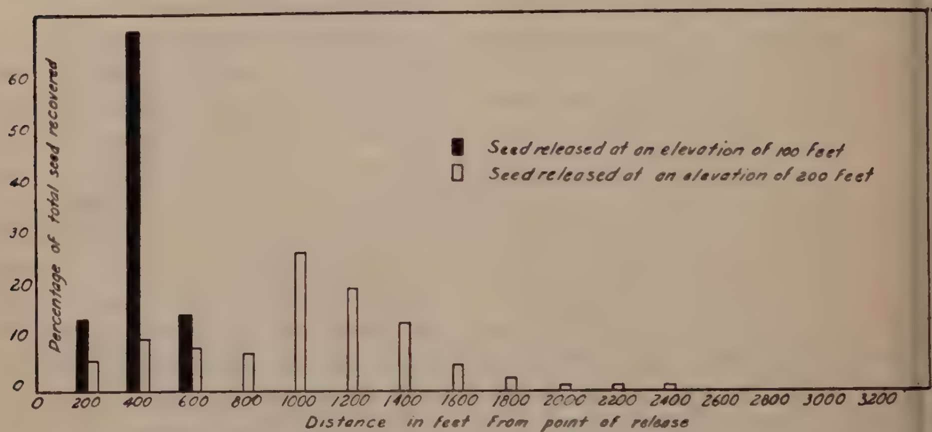

FIG. 1.—Effect of height of release on seed flight. Douglas fir seed released in a wind of seven miles per hour.

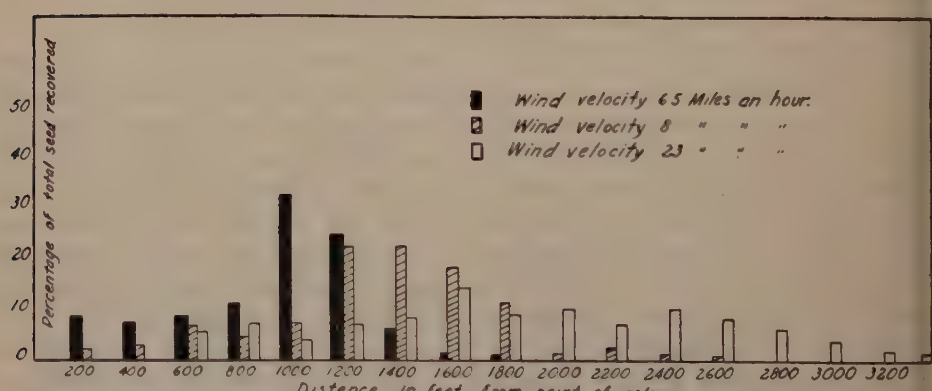

FIG. 2.—Effect of wind velocity on seed flight. Douglas fir seed released at an elevation of 200 feet.

The velocity of the wind during the time when seed is being shed is a prime factor in determining the distance to which it will be carried. This is brought out in the three tests of Douglas fir (Figure 2) wherein seed was released at a height of 200 feet and in wind velocities of 6.5, 8, and 23 miles an hour. In the 6.5-mile wind the heaviest fall

occurred at 1000 feet from the point of release, and the greatest distance at which seed was found was at 1800 feet. In the 8-mile wind the greatest densities of fall were at 1200 and 1400 feet, and the end of the flight was at 2600 feet. The test conducted in a wind velocity of 23 miles an hour showed the heaviest fall at 1600 feet and the extreme limit of flight at 3200 feet from the point of release. These tests indicate that increase in distance at which the heaviest fall takes place is somewhat less than directly proportional to the increase in wind velocity. However, the amount of seed which falls beyond the point of greatest density shows marked increase with the higher wind velocities. These results are corroborated by other tests not presented.

The distribution of western yellow pine, western white pine, and Douglas fir seed released at 150 feet in low wind velocities is shown by the results of three tests recorded in Table 3. Western yellow pine in a 3.5-mile wind showed the heaviest fall at 300 feet from the point of release, while Douglas fir in a 3.6-mile wind showed the heaviest fall at 500 feet. In higher wind velocities the two species were found to make almost equal flights. Western white pine in a wind of but 2.2 miles an hour showed the heaviest fall at 300 and 400 feet from the point of release, and at 800 feet showed a heavier seed fall than the foregoing Douglas fir test in a much higher wind velocity. Abnormally heavy fall of white pine seed at the 100-foot point occurred as a result of seed being held together by pitch and falling in a body.

Another comparison of the seed flight of the different species is shown by the series of tests wherein all seed was released at a height of 200 feet. Although the wind velocities were not the same in the different tests they were sufficiently similar to enable one to compare the powers of flight of the different species. Douglas fir released in an 8-mile wind showed the heaviest seed fall at 1200 and 1400 feet. The seed of western red cedar fell in a more compact body than that of the other species tested, in a 9-mile wind showing the heaviest fall at 1000 feet. Noble fir released in an 11-mile wind gave the heaviest fall at the 1400-foot point, which is similar to the fall of Douglas fir in an 8-mile wind. Western white pine in a 14-mile wind showed the greatest density of fall at 1600 feet and a comparatively heavy fall at 1800 and 2000 feet. But western hemlock with seed released in a 12.5-mile wind showed the greatest density at 2000 feet and an extreme limit of flight at 3800 feet, which is the most distant point at which the seed of any species was found.

Summary

Results obtained in both the seed trapping and the kite and balloon phases of this study indicate that the abundance of the crop, the height of release, the wind velocity, and the tree species all have a definite bearing on the distance and density of seed distribution.

The measurement of natural seed fall (seed trapping) from a timber edge shows that from the shorter woodlot type of trees the bulk of the seed falls within 100 feet of the timber, but from a heavy crop sound seed in goodly numbers (8,000 per acre) may be expected 900 feet from the edge of the timber.

From a light crop such seeding cannot be expected for more than half that distance. A comparison of dissemination from the short (150-foot) timber with

TABLE 2

DISSEMINATION OF WINGED SEED RELEASED FROM A BOX KITE AS SHOWN ON 4-FOOT CROSS STRIPS AT 200-FOOT INTERVALS. SEED WAS RELEASED AT AN ELEVATION OF 100 FEET IN THE FIRST TEST AND 200 FEET IN OTHERS

Species	Wind, miles per hour	Distance in feet from point of release															
		200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
		Per cent of total seed recovered															
Douglas fir	7	14	70	15	0.4	..	..	..	..	..	..	..	..	..	..	..	..
Douglas fir	7	5.5	9	8.5	7.5	27	20.5	13.5	5.5	2.5	0.2	0.1	0.1	0.2	..	0.1	..
Douglas fir	6.5	9	8	9	11	32	24	6	0.5	0.2	..	..	..	..	..	..	..
Douglas fir	8	2	3	7	4	7	22	22	18	11.0	1	2.0	0.2	0.2	..	..	..
Douglas fir	23	..	1	6	7	3	7	8	14	9	10	7.0	10	8.0	6	4	2
Cedar	9	..	..	17	18	36	17	4	6	0.8	..	..	..	..	..	..	..
Noble fir	11	9	12	5	6	8	12	21	14	6	4	3	..	..	..	..	..
Hemlock	12.5	..	0.8	5	6	7	4	2	6	12	25	12	3	11	2	1	3.4*
White pine	13	..	19	15	0.8	5	3	5	17	14	12	3	4	1	..	..	..

* Includes .5 picked up at 3400 ft., .5 at 3600 ft., and .4 at 3800 feet from point of release.

TABLE 3

DISSEMINATION OF WINGED SEED RELEASED FROM A PILOT BALLOON AT AN ELEVATION OF 150 FEET, ON 4-FOOT CROSS STRIPS AT 100-FOOT INTERVALS

Species	Wind, miles per hour	Distance in feet from point of release							
		100	200	300	400	500	600	700	800
		Per cent of total seed recovered							
Yellow pine	3.5	12.5	15.6	34.4	25.0	12.5	..	..	..
Douglas fir	3.6	1.1	4.5	9.0	22.4	29.2	20.2	11.3	2.3
White pine	2.2	20.7	13.8	17.2	17.2	13.8	10.3	3.5	8.5

that of a similar crop from the tall (210-foot) timber indicates that the seed of the latter will be carried twice as far as that of the former.

The kite and balloon tests show quite definitely the influence of height of release and wind velocity, also the variation between the flight of seed of different species. Seed of Douglas fir released at heights of 100 to 200 feet indicate that the increase in distance of dissemination is more than directly proportional to the increase in height of release.

In general the measure of natural seed fall from the timber edge indicates a shorter flight than that shown by the kite and balloon tests. This is probably due to obstructions to air movement by the timber itself and to the fact that high winds usually occur in moist weather when no seed is being released. The heavy fall of seed close to the timber is evidence that most of the seed is shed during periods of low wind velocity. Seed released in unobtrusive air currents, as from the kite and balloon, gives a distribution similar to that which may be expected from lone seed trees.

Air movement is exceedingly variable and great variations in distance of seed dissemination may occur. In this study an effort was made to measure dissemination under normal conditions in the region. The technic of field procedure may be of value if the study is extended to other species or other regions. The results of this study afford a measure of seed dissemination for the named species under the particular sets of conditions given and furnish a standard for comparison with other species and other regions.

FITTING FOREST PLANTING TO AMERICAN NEEDS

By PHILIP C. WAKELEY

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FREQUENTLY the cry is raised that we need distinctly new approaches to our important problems of various sorts, instead of blind repetition of outworn and inadequate methods. Among American foresters, there is a constant objection that the more or less formal silvicultural methods evolved in Europe do not fit our needs, and that we must develop distinctively American methods, better adapted to our tree species, climate, physiography and economic organization.

One of the most important and at the same time most troublesome forestry problems in the United States is that of planting the vast acreage of forest land which has been too badly devastated for natural regeneration. The problem is acute for extensive areas.

The need for such planting may be dismissed without comment. The acreage in need of artificial reforestation and the time and expense involved in the task are matters of estimate and conjecture, the more so because of the lack of any extended survey of forest resources to give us figures based on actual, systematic cruises. Even a few items culled from recent publications and correspondence are, however, enough to indicate the impressive size of the problem.

The Lake States, for example, are estimated to contain more than 20,000,000 acres in need of planting, an area which, at the rate of planting attained in 1926, would take 1,300 years to reforest artificially (4). A recent estimate (1) for the state of Michigan gives 1,390,000 acres of denuded land already reverted to the state for non payment of taxes, more reverting at the rate of 250,000 acres a year, and a total of more than 9,000,000 acres of unproductive lands still in private ownership. In discussing the needs of the Lake States for forest planting Kittredge (4) assumes 5,000,000 acres in need of planting by all agencies within any one state, and, taking 50 years as the limit which ought to be set on the program of reforestation, outlines a plan for planting 100,000 acres a year.

Various figures for New York give 2,000,000 acres of abandoned farm land available for forest planting, 275,000 additional acres being abandoned annually, and 1,000,000 acres of abandoned farm land now available in blocks of 500 or more acres at $10 or less an acre (6). A published estimate (2) gives 200 years as the time required to reforest the lands now in need of planting in New York.

A federal bulletin now due from the press will probably give 10,000,000 acres as the area needing planting in portions of eleven states lying in the southern pine region. N. C. Brown (2) gives 33,500,000 as needing planting in nine of these eleven states, a figure which the writer, on the basis of more detailed data from other sources, believes to be high. Fig-

ures furnished the writer by state and extension foresters in five of the eleven states total 9,750,000 acres needing planting, although the acreages are at best based on shrewd estimates checked by data collected for other purposes. It seems likely that the figure of 10,000,000 acres is very conservative for this region.

Half a million acres are estimated to be in need of planting in Washington and Oregon (5), and there are vast areas, many of them originating from fires, needing planting in the northern and central Rocky Mountains.

The Forester's report for 1928 (8) gives a total of more than 2,100,000 acres needing planting on the national forests alone. At the rate of planting attained in 1927, the reforestation of this acreage would require nearly 170 years.

The best estimates we have of the total area needing planting in the United States are in excess of 80,000,000 acres (3, 2,) much of it concentrated in a few regions instead of being evenly distributed and readily handled by local resources. Under present planting practice, the cost of reforesting this area may be almost anything in excess of $500,000,000. The time assumed necessary to complete the work at the present rate is in the vicinity of 900 or 1000 years (2, 7).

The distinctively American problem, then, is not planting in connection with organized forestry operations, where planting costs are a regular part of current expenses and where a variety of silvicultural measures are entirely feasible, but the artificial reforestation of a stupendous area, and particularly the more extensive portions thereof, left bare by abandonment of agriculture, by lumbering, and by fire. Funds are hard to get for this task of planting, and the size as well as the urgency of the job increases as time goes on. We may even find, before we are through, that available seed is a limiting factor in the work.

Now for a new approach to our problem. The logical procedure is to make the trees we plant do part of the work for us. In other words, we should plant many of our more extensive areas of non-reproducing land in such a manner as to permit the seeding of half the area from trees planted on the other half. Planting alternate strips, perhaps 100 feet wide, and if possible at right angles to the winds prevailing at time of seeding, would be the simplest application of the method, which after all is nothing but the old European scheme of clear cutting in alternate strips, remodelled to fit conditions never dreamed of in western Europe. Modifications would include mixtures of species, with particularly early and aggressive seeders in continuous rows or scattered groups along the outer edges of the planted strips.

Since trees ordinarily produce abundant seed before attaining the most economical merchantable size, the planted strips would have plenty of time to seed the unplanted strips between them before the rotation was complete and the planted crop ready for harvest. Thus the suggested method of planting in strips, after the series of strips first planted began to produce seed, would practically double the area that could be reforested in the period represented by one rotation.

The working of the method is shown schematically in Fig. 1, in which the total area of the strips planted in any one decade is represented by a black bar; the total area of interspersed strips reseeded, during a decade, from the adja-

cent planted strips is represented by a cross-hatched bar; and areas of non-reproducing land are represented by white. It is assumed that the species used begin effective seed bearing when 30 to 40 years old, and that the trees are to be grown on an 80-year rotation, figures which are certainly conservative for many localities. The diagram shows the progress of reforestation by 2050, providing equal areas are planted each successive decade beginning with 1931. It can readily be seen that during the first 30 to 40 years, 1931 to 1970, the total reforested area will be only that actually planted. From 1971 on, however, each decade's planting, as *A, B, C,* will be matched by an approximately equal area, as *a, b, c,* seeded by natural means from adjacent planted strips which have reached seed-bearing age. From 1971 to 2050, or one rotation, the total area reforested will thus be *A-H* plus *a-h,* or twice the area that could be reforested by planting alone during the same period.

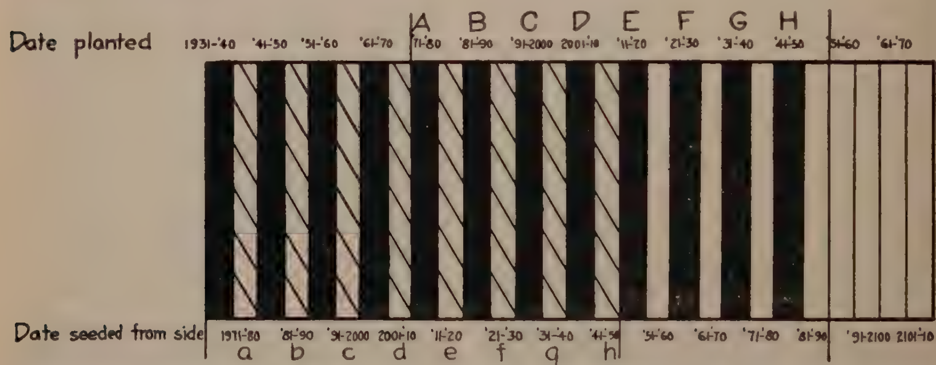

FIG. 1.—Diagram showing total area reforested by 2050, assuming alternate strip planting to have started in 1931 and progressed at a uniform rate. Rotation, 80 years. Age of effective seeding, 30-40 years. Black represents planted areas; cross-hatching, areas seeded naturally from side; white, areas not yet reforested.

The method, to be sure, would result in the immediate restocking of only half of any given tract of land, and at the same time would require more skill and more overhead expenditure per thousand trees planted than would the present system of covering the entire area as the job progresses. Furthermore, the broken nature of the resulting stand would undoubtedly increase the cost of future logging. These disadvantages, however, would be offset by the more rapid reclamation of waste areas as a whole, and by the natural regeneration, at a cost little greater than that necessary for protection, of approximately half of the total area to be reclaimed.

The edges of the planted strips would yield timber of lower quality than that from the center of solid stands, but this disadvantage would be offset in the long run by the uneven-aged nature of the forest as a whole, desirable from the standpoints of both protection and cultural treatment.

The method has the undeniable disadvantage of leaving half of the total soil surface exposed for many years to erosion, desiccation, and the invasion of brush, but has the compensating advantage, if natural reproduction does not

take place as planned on the originally unplanted strips, of permitting the later artificial mingling of species over large areas, or the introduction of species afterwards found more desirable than those first planted. If worst comes to worst, and the unplanted strips are reproduced neither naturally nor artificially until the planted strips are cut, then at least the ultimate cost of reforesting the area as a whole may be borne in part by the crop raised on the planted portion during the first rotation.

In many regions, as in the South and West, the returns from grazing in the unplanted strips might help carry the cost of the initial planting. The method might also prove advantageous from the standpoint of game management.

The method will probably not prove applicable on many private holdings. Few lumber or paper companies in a position to practice forestry have a planting problem of such magnitude that it will take them a rotation to plant half their barren land. Even if their non-reproducing areas were of such extent, the complications involved in assessing and taxing lands planted in alternate strips might prove a discouraging obstacle. The state and federal governments, however, with more bare land in sight than can be planted in five or ten rotations, are in an altogether different position, especially when some of the land is so situated, economically or topographically, that it should not or cannot be logged for many years to come, no matter what the nature of the stand established.

It is hoped that some enterprising district or department with a 500-year planting job ahead of it will try the suggested method in the field.

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DESIRABILITY OF A BROADER NATIONAL POLICY OF FOREST PLANTING

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Introduction

THE inevitable denudation of forest lands which follows in the wake of the economic and industrial development of a new country is resulting in an ever-increasing amount of nonproductive forest land in the United States. According to "American Forest and Forest Products" (14) there was estimated to be 81,200,000 acres of forest land in the United States in 1920 which would need artificial planting before it could be brought into a productive state. This vast area was originally forested and is suited only to forest use. This figure is almost identical with that given in the "Capper Report" (16) of June, 1920. This report also states that 5,000,000 acres are being added to that total annually.

Show (10) states that from 300,000 to 2,000,000 acres of the total of 16,000,000 acres of forest land in the California pine region are so devoid of timber or reproduction of any value that planting will be necessary.

Munger (5) states that 40 per cent of 200,000 acres being cut annually in the Douglas fir region of Oregon and Washington is not reproducing useful tree growth.

Zon (18) places the area of denuded forest land in Minnesota, Wisconsin, and Michigan at 20,000,000 acres.

Statistical Bulletin No. 21 (14) states further that "The adjusted 10-year average for forested land burned over annually in the United States is 11,865,418 acres, based on the period 1916-1925, inclusive." Some of this is re-burn, of course. There are no very accurate figures on the percentage of recently burned-over forest areas which will need replanting. Furthermore, it must be remembered that the figures noted above are estimates subject to variation. They are, however, the best figures available and are perhaps conservative.

Assuming that 1 per cent of recently burned areas will need replanting, we find that the acreage entirely denuded annually by fires is slightly more than that being planted. In the aggregate, therefore, little or no real headway in forest planting is being made from the "acreage" standpoint if the 1 per cent assumed above is anywhere near correct. Even if no further forest denudation were taking place it would require, at the rate of planting up to 1927, about 900 years to put present denuded forest land in a productive state. What future can there be for forestry if a momentous problem is to be met with such a feeble effort? Either the present rate of planting must be increased many-fold or a more effective method of reforesting adopted if the problem is to be dealt with adequately.

There was planted in the United States, to and including the year 1925, the following (14):

	Acres
United States Forest Service.	211,877
States	113,520
Municipalities	24,922
Industrial organizations	91,426
Other organizations, associations, and clubs.........	4,018
Schools and colleges........	1,809
Individuals (mostly farmers)	1,179,087
Total	1,626,659

Pack (7) estimates that in recent years about 90,000 acres of forest land are being planted annually in the United States by all agencies. Of this acreage the United States Forest Service plants 13.3 per cent, based on acreage planted in 1926 and 1927. According to Olson (6), increased appropriations resulted in the planting of 18,000 acres in 1928 and much more progress is being made now than formerly.

The present rate of planting seems, however, even more inadequate when the acreage planted is compared with the nearly 44,000,000 acres burned over as a result of forest fires in 1928. Furthermore, the season of 1929 probably surpassed 1928 in total area burned.

Faced with such an array of discouraging statistics the American public can be assured of an ultimate famine of timber products unless greater funds are soon made available for the protection of existing timber stands and either greater funds provided for planting or planting methods greatly improved over those now employed. What hope can there be for a tenfold increase, let us say, in funds for planting? Very little! What hope is there of the present planting system meeting the needs of reforestation without at least a tenfold increase? Absolutely none! What, then, will be the answer?

A great deal of thought has been given in recent years to the matter of bringing about more rapid reforestation of denuded forest lands. Planting a small percentage of such lands for the express purpose of securing desirable seed trees has been formally and informally discussed. In several cases small areas have been planted to test the system. The writer is indebted to Weidman (17) for the following statement:

"Austin Cary prepared a written memorandum suggesting strip planting after the fires of 1910. The proposal was discussed at an annual investigative meeting in which I participated over ten years ago in District 6. It also came up in our District 1 annual investigative meeting in January, 1923, and a paragraph is devoted to it in our annual report for that year. As a result of the discussion at that time, the Office of Planting actually tried out the scheme on a small scale that year on the Clearwater Forest."

Lowdermilk (4) also refers to the action mentioned by Weidman and states further:

"I have personal knowledge that the method was actually used by Mr. Joseph Bailey in famine relief work in China whereby Purple Mountain near Nanking was reforested in part by famine laborers. The method employed was the planting of pine trees (*Pinus massoniana*) on ridges in rows and in groups to permit reseeding as the trees bore seed. I may say that in making studies of the results of this method some years later, I found that reseeding was taking place in a satisfactory manner."

However much thought has been given this problem of restoring denuded forest lands to a productive state, there is no concrete evidence that adequate advances have been made in the rate of planting or otherwise restoring production on the devastated acres.

"Spot Planting" a Possible Solution

The results of the forest survey now being instituted in the United States should give an excellent basis for determining the adequacy of the present planting policy. Regardless of future information, however, the evidence already strongly emphasizes the insufficiency of the present planting program. Thus the important question arises "What system of planting will meet the demand?"

It is the purpose of the author to revive for further consideration the "spot-system" of planting for coniferous forest regions of the United States where natural seeding may be relied upon to provide satisfactory reproduction on denuded areas. Inquiry indicates that the "spot-system" as considered in recent years is primarily a "crisscross" or "gridiron" system whereby small plantings are made at certain standard intervals. Most consideration seems to have been given the matter of interval without attaching sufficient importance to the silvicultural qualities of the planting sites. Interval and spacing are matters which are determined largely by factors influencing seed dissemination from the desired tree species in the locality where planting is to be done, and must be given due consideration.

However, site quality is of major importance in selecting spots for planting seeding nuclei and must receive prior consideration primarily because the success of "spot-planting" would depend on good survival, rapid growth, and early seeding, and secondarily because such favored spots would usually represent only a small percentage of equally good site for given species and seed produced by the planted trees would fall on "fertile ground." Toumey (13) says that classification of sites into quality classes irrespective of species is of little value and that a first quality site for one species may be a second quality site for another or *vice versa.* Regardless of species to be planted there would, of course, be much acreage in many regions of lower quality than site 1. Here the best sites for growth of planted stock commensurate with future possible seed dissemination should be chosen for "spot-planting."

It is fully recognized that much difficulty, varying with the severity of topography, would be met in selecting spots from which ideal seed dissemination could be secured. Furthermore, it would frequently become necessary to plant on spots where soil and moisture conditions are far from ideal. There is much potential coniferous forest land in the United States where the "spot-system" of planting with the expectation of natural reseeding of denuded areas would be almost a complete failure. Primary causes for such failure would be: (1) Excessive drought; (2) heavy consumption of seed by rodents; and (3) impoverished soil. The factors mentioned are of varying degrees of importance but they are nevertheless primary in their limitation of reproduction from natural seeding. As an example of this Show (10) states that direct seeding fails in much of the California pine region be-

cause of the consumption of seeds by rodents or by reason of excessive drought.

There are other regions of the United States where similar conditions prevail. On the other hand there are many regions such as the Douglas-fir region of western Oregon and Washington, the white-pine belt of the Inland Empire, the bulk of the coniferous forests of the Lake States and New England region, and much of the pine forest of the Southeastern and Southern States where natural seeding is successful in a large measure.

In a rugged region one of the most important problems is future seed dissemination. Areas selected for planting should be chosen with this in mind. Full consideration should be given to prevailing winds as the future seed carriers. Generally, soils in bottoms, on moist lower slopes, along streams and draws, and on upland draws and benches where proper moisture, fertility, and protection from weather extremes are afforded, represent the most ideal conditions for seed "catch," as well as for survival of planted stock. Furthermore, the most valuable part of the original timber stand probably grew on or near these favorable sites and the same may be expected of future crops. Therefore, plantings should be made at points which will permit excellent seed dissemination to all these favorable sites.

The correct distance between planted spots should be determined after considering the timber species, the local and prevailing winds, the topography and other factors, and the distance seeds are normally disseminated. There are records of Douglas-fir trees in a solid body disseminating seed satisfactorily for at least a quarter of a mile. On the other hand the heavy seed of sugar pine would not be carried very far by the wind. The normal distance to which seed is disseminated from each tree species under given conditions must be known before the "spot-system" of planting can be successfully applied. The following information for some of the important conifers is of the nature needed for each region:

1. Douglas fir (*Pseudotsuga taxifolia*). Seed scattered $\frac{1}{4}$ mile or more in a good wind.

2. Loblolly pine (*Pinus taeda*). No actual records found but it is known that the seeds are scattered relatively long distances.

3. Shortleaf pine (*Pinus echinata*). Relatively long distances.

4. Bigtree (*Sequoia washingtoniana*). Relatively long distances.

5. Sugar pine (*Pinus lambertiana*). 150 yards from high trees.

6. Western yellow pine (*Pinus ponderosa*). 100 to 150 feet; $\frac{1}{4}$ mile in the Southwest in a high wind. (13)

7. Northern white pine (*Pinus strobus*). 100 to 200 feet; $\frac{1}{2}$ mile from ridges.

The volume of seed produced is an important factor in securing good dissemination, not because the seed will carry any farther from large than from small groups or single trees but because the greater volume of seed permits the area reached to get a much heavier showering of seed. The interval between planted spots would thus depend, to a large extent, on the distance to which seed of the desired species could be disseminated as determined by the size, weight, and character of seed, the height of trees above surrounding ground area, and the direction and severity of prevailing and local winds.

Another very important consideration would be the age at which the various tree species begin to produce viable seed in satisfactory quantities for seeding of extensive areas. Table 1 is a partial showing of such information as would be necessary to apply successfully the "spot-system" of planting. However, the table shows only when the first cones are produced, and these usually do not contain viable seed. There is much conflicting information regarding the time of seeding and there is undoubtedly much variation by regions. At any rate the table stresses what is needed.

It is evident that under the "spot-system" of planting good crops of viable seeds can hardly be expected in less than 20 to 40 years after planting of most of the important species.

TABLE 1

TIME REQUIRED FOR CONE PRODUCTION

Species	Age Cones First Produced	Region	Authority
Lodgepole pine (*Pinus contorta*)	15 years.	Intermountain lodgepole pine belt.	M. W. Thompson (12).
Jeffrey pine (*Pinus jeffreyi*)	Late in life.	Central Sierras in California.	Silvical leaflet (15).
Bigtree (*Sequoia washingtoniana*)	18 years in the open, later in forest.	Western slopes of the Sierras and in Coast Range of California.	Silvical leaflet (15).
Western hemlock (*Tsuga heterophylla*)	25 to 30 years.	Northwestern States.	Silvical leaflet (15).
Western white pine (*Pinus monticola*)	13 years.	Clearwater National Forest, Idaho.	P. A. Wohlen, supervisor Clearwater National Forest.
Western white pine (*Pinus monticola*)	20 years and older.	Inland Empire.	Silvical leaflet (15).
Sugar pine (*Pinus lambertiana*)	40 to 45 years.	Southern Oregon and northern California.	L. T. Larsen (3).
Douglas fir (*Pseudotsuga taxifolia*)	6 years.	Oregon, nursery-grown tree.	T. J. Starker, School of Forestry, Oregon State College.
Douglas fir (*Pseudotsuga taxifolia*)	25 years and older.	Oregon and Washington.	T. T. Munger (5).
Englemann spruce (*Picea engelmanni*)	25 years and older.	Rocky Mountain region.	G. B. Sudworth (11).
Loblolly pine (*Pinus taeda*)	Early in life.	Southern States.	W. R. Mattoon.

For reasons already discussed it would be impractical to prescribe the size of groups to plant, number of trees per group, distance between groups, and per cent of total area to be included in the planted spots for general use. For a given

region, however, this might be done accurately. Let us consider, as an example, the coast Douglas fir region of western Oregon or Washington where the predominating coniferous tree species are Douglas fir, western red cedar, and western hemlock. Seeds of all three species are relatively light and easily carried by winds. Quite severe winds from various quarters are frequent while the cones are opening. Hence the distance between groups might range roughly from 300 feet in coves and protected spots to a quarter of a mile on upland exposed situations. The three species are comparatively prolific seeders and forty or fifty trees or even less on one-twentieth or one-tenth of an acre, say, might well be considered sufficient as a seeding nucleus. It might, however, become necessary to plant larger groups as a protection against windthrow or other damage by weather extremes under exposed conditions.

The advantages of planting by the "spot-system" are:

1. Denuded areas would be placed on a partially productive basis at a tremendously increased rate over the rate of planting by methods now in use.

2. Much less of the planted stock would be exposed to loss from fire than where entire areas are planted, because much of the stock would be planted along streams, in draws, and on otherwise protected spots. Furthermore, there is far less planted stock at stake on any given area than where entire areas are planted.

3. Greater survival and better growth of planted stock would result because of the more favorable conditions on the selected spots.

4. Better seed trees as a result of better planting sites should result in stronger individuals in the crop of reproduction and therefore in a better stand of timber at maturity.

5. In regions where white-pine blister rust is a menace planting sites can be so chosen that susceptible timber species will receive the maximum degree of natural protection possible. A certain degree of control over other diseases might be possible. Furthermore, proper selection of planting sites might result in protection to the planted stock against forest insects.

Summary

Forest devastation in the United States has continued at an alarming rate. Logging practices, other industrial development, fires, insects, and diseases have contributed to this condition. An enormous acreage of forest land is already denuded to such an extent that artificial means of reforesting will be necessary. In addition more forest land is being denuded annually than is being planted. This ratio will continue unless greater expansion of the planting program is effected and further devastation reduced to a minimum.

The normal expansion which may be expected in the present program of planting areas completely cannot solve the problem. Some method of obtaining a more rapid return of denuded forest lands to a productive status is essential. The author believes that partial planting for the purpose of securing nuclei of trees to reseed the balance of the denuded area is a promising substitute for the present planting method in regions where natural seeding is followed by satisfactory reproduction. It is the purpose to revive consideration of the "spot-system" of planting to accomplish the desired end.

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SUITABILITY OF THE LILJENSTROM DENDROMETER FOR READING DIAMETERS OF TREES IN BLACK WALNUT PLANTATIONS

By ROBERT K. WINTERS

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THE yield study of black walnut plantations under way at the Central States Forest Experiment Station necessitated the construction of a volume table for plantation-grown trees of this species. Since but few of the planted areas contained merchantable material, and since in practically none of them were cuttings being made, the usual method of taking volume table measurements could not be employed. Tests were accordingly made with the Liljenstrom dendrometer, an instrument used in European practice to measure the upper diameters of standing trees, in the hope that it would give sufficiently accurate results for the purpose of volume table construction.

This dendrometer is a telescopic instrument, mounted on a tripod, and equipped with a level, a vertical arc, and a scale etched in glass in the eyepiece to perform a function similar to that of the stadia hairs in a transit. It is set up at a known distance from a given tree and levelled in the usual fashion.

To determine the height of the tree a sight is first made on its base, and the vertical angle read in degrees. A sight is then made on the tip of the tree and the reading on the vertical scale again noted. These angular units are converted into tree height from two sets of tables, one in metric and the other in English units, covering distances from the tree of 10 to 25 meters. The diameter at any point is determined by reading on a graduated scale in the telescope of the dendrometer the number of graduations between the two outer edges of bark on the trunk and multiplying this number by the proper factor as shown in the tables for the given distance and vertical arc reading.

The dendrometer is best suited for measurement of diameter at fixed intervals up the stems of standing trees, as in volume table construction, where it might be desired to secure diameter measurements at 8.15-foot units from stump height. To do this, the dendrometer should be set up at such a distance from the tree that the top is easily seen through the telescope without making too large an angle with the horizontal plane. Suppose, for example, that this is 10 meters, and that the vertical distance from the base of the tree to the horizontal plane is found by the method just described to be 4.2 feet, and that one foot is allowed for stump height. Then the point at which the first diameter measurement is to be taken is 9.15 minus 4.2, or 4.95 feet above the horizontal plane. From the Liljenstrom tables for a 10-meter distance a vertical arc reading of 8.5 is seen to correspond to 4.95 feet above or below the horizontal plane.

Elevating the telescope so that the reading on the vertical arc is plus 8.5, the point at which the horizontal crosshair cuts the tree trunk is the point at which the first diameter measurement should be taken. The observed width of trunk at this point expressed in mills is then multiplied by 0.398, the value found in the table corresponding to the height 4.95, to get the diameter of the tree in inches at this point. The diameters at other points on the stem are obtained in a similar manner.

In order to test the accuracy of the dendrometer, diameter measurements were taken with it on twenty-seven plantation-grown black walnut trees at 1, 2, 3, 4, 5, 9.15, 17.3, and 25.45 feet above the ground, and so on by 8.15-foot intervals. In addition, a measurement was taken at a point halfway between breast height and the tip of the tree. The dendrometer was used to determine both the diameter and the point on the stem at which it was to be measured. Check measurements were made by climbing the same trees, measuring distances from the ground with a 100-foot steel tape, and taking diameters with a diameter tape.

Errors in diameter estimation varied from minus 55 per cent to plus 57 per cent, with most of the errors falling between minus 10 per cent and plus 10 per cent. In general the larger errors came with the smaller diameters, indicating decreasing accuracy with increasing height. Analysis of the errors and of the manner in which they occur suggests the following sources of error in reading diameters with the dendrometer:

1. An accurate reading of the graduations on the crosshair scale of the instrument is difficult.

2. The dendrometer does not accurately measure stem heights on black walnut trees.

3. One diameter only is measured at a given height.

Accurate reading of the crosshair scale in the telescope is influenced greatly by the personal equation of the instrument man. This scale measures the tree diameter in much the same manner that a Biltmore stick does. Each graduation is divided into tenths by personal estimate, and for small trees, such as are found in walnut plantations, an error of two tenths of a unit in estimate corresponds at 72.2 feet from the tree, to approximately two tenths of an inch error in diameter.

Definition of the precise edge of the stem is difficult where crown shade is dense or where another tree stands approximately in line with the tree being measured. The bark of the two trees appears to blend until the observer is unable to tell when the zero graduation is at the edge of the trunk.

The telescope of the dendrometer is so constructed that movement of the eye of the observer from the center of the eyepiece may cause an error as great as four tenths of a scale graduation.

Some observers find that the scale graduations fade from sight during continued concentration upon a given point. This fading is probably an optical illusion caused by fatigue of the muscles of the eye.

On account of these sources of error, two men might read different diameters for the same point on any given tree, and this has actually happened upon several occasions.

In addition to these errors arising from the personal equation, the wind

makes accurate reading of the upper diameters practically impossible. Tops sometimes sway as much as two feet, and at practically no instant on a windy day are they still. The best that can be done is to make an attempt to estimate the diameter at the extremities of the swing. Such estimates are necessarily only approximate, and errors as great as one inch in diameter can arise from this source alone.

Table 1 gives the results of measurements taken on sample trees on a windy day and on a still day. It is apparent that on a windy day the percentage of error increases greatly above a height of 17.3 feet. The total height of tree No. 10 was 44.3 feet as measured by the dendrometer and 41.75 feet by the 100-foot steel tape; while that of tree No. 15 was 58.2 feet by the dendrometer and 57.0 feet by the Abney level.

As the wind sways the stem from one side to another, the dendrometer measures the diameter of the tree at the proper height—providing it is vertical when no wind is blowing—only when the tree is at the center of its swing. A diameter reading at this instant is a physical impossibility. The result is that in probably 80 per cent of the higher measurements taken on windy days the dendrometer diameter is actually taken too high on the stem.

The crosshair scale has been observed to move up and down the stem of a swaying tree for a distance of 10 to 14 inches. An error of this amount in certain instances would mean the taking of a diameter above a limb when it should have been taken below. This source of error can be practically eliminated by observing the lowest point at which the crosshair scale cuts the swaying tree, and depressing the telescope until the scale cuts this point when the tree is at the extremity of its swing.

However, the error in measuring heights with the dendrometer cannot be overcome on those trees that lean, or have certain portions of their stems leaning. As black walnut does not characteristically have a central stem, measurements must be made on one of the

TABLE 1

COMPARATIVE ERRORS IN DIAMETER MEASUREMENTS MADE ON WINDY AND STILL DAYS

Height above ground, feet	Tree No. 10, windy day: Diameter outside bark: Dendrometer, inches	Tree No. 10, windy day: Diameter outside bark: Diameter tape, inches	Tree No. 10, windy day: Error, per cent	Tree No. 15, still day: Diameter outside bark: Dendrometer, inches	Tree No. 15, still day: Diameter outside bark: Diameter tape, inches	Tree No. 15, still day: Error, per cent
1	6.0	5.9	+ 1.7	11.4	11.6	−1.2
2	5.4	5.5	− 1.8	10.2	10.2	0.0
3	5.5	5.2	+ 5.8	9.7	9.8	−1.0
4.5	5.3	5.0	+ 6.0	9.5	9.5	0.0
9.15	4.8	4.4	+ 9.1	8.9	9.0	−1.1
17.3	3.9	4.0	− 2.5	8.4	8.0	+5.0
24.4	2.9	3.3	−12.1	..	..	..
25.45	2.4	3.2	−25.0	7.8	7.2	+8.3
31.3	..	..	..	6.5	6.7	−3.0
33.6	2.2	..	..	6.2	6.3	−1.6
41.75	..	..	..	3.7	4.0	−7.5
49.9	..	..	..	1.5	1.5	0.0

important branches. In practically all cases they lean either toward or away from the observer at some point along their course. In some cases they fork in such a manner as to lean first one way and then another. As the greatest variation from the perpendicular is found in the upper stem where the angle from the instrument to the point of measurement is relatively steep, the error in height is greater than it would be at lower points.

In order to check the accuracy of height determinations by the dendrometer, heights of certain trees were read from the dendrometer and also measured with a tape.

The resulting errors varied from minus 5.7 to plus 5.1 per cent, with 88 per cent of the total number of measurements showing errors between minus 3 per cent and plus 3 per cent, and with no significant relation between the amount of the error and the height at which the measurement was made.

The fact that the dendrometer measures only one diameter results in error on trees that are not circular in cross section or that have irregularities on either edge at the point of measurement. In one tree errors of 18.4, 19.8, and 12.7 per cent were found in diameter measurements 1, 2, and 3 feet from the ground because of a swelling caused by a large root.

The use of the dendrometer has an advantage over climbing in that it allows readings to be taken more rapidly. However, the errors to which it may give rise so much more than counterbalance this advantage that its use was discontinued in the taking of data for the construction of the black walnut volume table.

RELATION OF FOREST RESEARCH TO THE NAVAL STORES INDUSTRY[1]

By E. L. DEMMON

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THE production of naval stores is one of the leading industries in the southeastern United States. Not only does it rank next in importance to agriculture and lumbering for the region as a whole, but also, particularly in Florida and Georgia, many communities are absolutely dependent upon it for their continued existence.

The term "naval stores" is applied to the products derived from the distillation of the crude gum or oleoresin which exudes from pine trees when the wood is cut. The name has come down to us from colonial times, when this industry produced principally pitch and tar, two commodities which in those days were important to builders of wooden ships and to the shipping trade. Now, however, the bulk of these products are resin, used in the varnish, soap, and paper industries, and spirits of turpentine, used in the paint and varnish and synthetic camphor industries.

The crude gum is obtained from the trees by wounding them at regular intervals to cut through the resin ducts in the outer layers of the sapwood. Each week a fresh wound ("streak") is made above that of the week before, the series of "streaks" forming a "face" of exposed wood on the side of the tree. The resin exuding from the freshly cut wood trickles down the "face" into a clay or metal cup. The resin ("gum") is dipped out periodically and taken to the still, where it is mixed with water and heated. The spirits of turpentine are then distilled off in mixture with water vapor, the turpentine separating from the water upon condensation. The residue left in the retort is resin.

The two trees which are the main source of naval stores in the United States are the longleaf pine (*Pinus palustris*) and slash pine (*P. caribaea*). These two pines are found widely distributed throughout the Coastal Plain of the southeastern United States. The slash pine is somewhat more restricted in its range than is the longleaf but over extensive areas these two species occur together. Their natural range covers about 90,000,000 acres, of which 70,000,000 acres are available at the present time for the production of timber and other forest products.

From these 70,000,000 acres of forest land the original stand of timber for the most part has been harvested. The remaining virgin stands of pine are concentrated in the western part of the region and these are rapidly disappearing; in another 20 years the original forest growth will be practically gone. Second-growth timber has come in on much of the cut-over area and the size, density,

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and age of these younger stands depends on the length of time since the original cutting took place, the number and effectiveness of seed trees that were left, and the influence of fire, grazing, and other factors.

It is a striking fact that the center of naval-stores production now lies in the region where the most extensive and oldest stands of second growth are to be found, namely in Georgia and Florida. These two states furnished 78 per cent of the United States production of naval stores in 1928.

Most of the 70,000,000 acres of cut-over land will not be needed for agricultural purposes for many years to come. Their utilization for the production of timber and other forest products, including naval stores, offers the best practical means of keeping lands productive that otherwise would be for the most part idle. Many farmers in the turpentine-producing region are owners of second-growth pine timber from which they obtain a current revenue by working the trees for naval stores. In this vast territory it is unusual to find a settlement without a turpentine still.

The market for naval stores products is firmly established—for the last five years the value of these products in the southern States has averaged a return to the producers of upwards of 50 million dollars annually. The United States production in 1928 was 28 million gallons of spirits of gum turpentine and nearly 800 million pounds of resin, or over 65 per cent of the entire world's production. Over 50 per cent of the United States production is exported. The remainder is used in domestic industries, principally in the manufacture of soaps, paint and varnish, paper, drugs, camera films, and a great variety of minor products.

The advantages which the naval stores industry offers to the South mark this region as one of exceptional promise from the standpoint of timber growing. The area of potential land suitable for the growth of turpentine pines is immense, soil and climatic conditions are favorable to tree growth, the market for the products is well established, and labor is plentiful and cheap. Because southern pines reach turpentine size in from 15 to 25 years, naval stores make possible early and intermediate returns and under proper practice the working of trees for naval stores will interfere but little with their future value for pulpwood, poles, posts, piling, railroad ties, and sawtimber. The returns from naval stores add to the total profits of the forest enterprise.

In America the methods of extracting the gum from the trees have undergone but few changes since colonial times, and are economically wasteful and silviculturally detrimental. Even yet most naval stores producers look upon their operations as temporary, notwithstanding the fact that there are numerous examples of trees which have been worked conservatively and continuously for many years and that new stands are coming into production every year.

One of the most wasteful phases of current naval-stores practice is the chipping of half-grown trees, just large enough to hold a cup. Although it ruins the trees for future production of naval stores or sawlogs, without at present yielding enough gum to return a profit to the operator, this premature chipping is more prevalent now than ever before. In the southern United States the destruc-

tion of second-growth timber through turpentining of small trees is exceeded only by the damage from forest fires. Working of this small timber has the additional serious effect of increasing the total production, with a consequent general lowering of prices for the product.

The permanence of the naval stores industry is dependent upon the development and general application of methods of turpentining which will assure the continuous health and growth of the trees and continuous replacement of the stands, and at the same time yield a profit to the operator. The great number of comparatively small holdings throughout this large territory make this industry somewhat analagous to agriculture in that the individual farmer or turpentine operator is not equipped and cannot be expected to conduct the research work necessary for the development of improved methods. To carry on this research, well-equipped laboratories are essential and field experiments must be made under technical direction.

Among the earliest attempts at research in the naval-stores industry in America were those begun in 1901 by Dr. C. H. Herty, of the old Bureau of Forestry. His influence was largely responsible for the introduction of the cup system in place of the very destructive "boxing" system in vogue until that time. Naval stores research has expanded greatly in recent years under the direction of the United States Forest Service, and includes administrative tests on the Choctawhatchee National Forest in northwest Florida, extensive field tests initiated by Dr. Austin Cary, physiological work conducted by Dr. Eloise Gerry of the Forest Products Laboratory, and intensive field experiments at the Starke, Florida, branch of the Southern Forest Experiment Station. The Bureau of Chemistry and Soils of the Department of Agriculture has also carried on some research work in naval stores problems, dealing mainly with the quality of the final product through the development of improved stilling practices.

Without appreciably impairing the vigor of the stand or lowering its value for wood production, it may be possible to increase the yielding capacity of the trees, either by modifying the present French and American methods of extracting gum, or by devising entirely new methods. In other words, timber stands should be managed to produce, over a period of years, the maximum yields of gum compatible with the devolpment of the trees for other products.

Investigations designed to conserve timber and increase gum yields include studies of modifications of existing methods to determine the optimum amount of wood to remove at each wounding (depth and width of streak, and width of face), the interval of chipping (weekly or otherwise), the duration of working throughout the year (32 streaks between March and November is average), the best type of tools, and the relative efficiency of the various kinds of equipment now in general use by the industry. Some of the methods of chipping which appeared to offer the most promise in preliminary small scale trials are now being tried out on an enlarged scale which will insure reliability of the results. These results must be checked in various parts of the southern pine region before they can be recommended for general use.

Another investigation is that of gum yields as related to such factors as size

of tree (diameter, height, and crown size), quality of the soil (site), density, age, and composition of the stand, vigor of trees as indicated by general appearance and current growth rate, and weather and soil relationships (rainfall, temperature, evaporation, sunlight, wind, soil moisture, and soil temperature as affected by time of the day and season of the year).

The relationship between naval stores operations and silviculture is one of the important problems in need of investigation. It involves studies of the relationship of the naval stores operations to tree growth, of the effect which non-gum-producing species of trees in the stand exert upon gum production, of the effects of spacing and thinning out of trees at different periods, by turpentining to death or otherwise, of natural regeneration of stands by leaving trees for seed, preferably high gum producers, or by other methods of turpentining and cutting, and of the effects of grazing and other land uses upon gum production.

Another important problem awaiting solution is the relation of naval stores production to the management of the stand for the production of timber and other forest products. This involves the application of silvicultural studies as well as a study of the effects of turpentining upon the quality of the wood for lumber or for other uses (poles, posts, piling, railroad ties, pulpwood and others). The effects of turpentining on the wood in the tree will naturally vary with the size of tree, with its resistance to mechanical injury, with the frequency and intensity of fires, with the method of turpentining, and the like.

It may be possible to increase yields by planting pine trees in orchards, by cultivating the soil, or by the use of fertilizers. In this connection, methods of improving yields by selection of plant stock from high-yielding, disease-resistant trees should undoubtedly be tried. Wide variations in yields from similar sized trees growing under similar conditions have been found. There is an excellent possibility therefore of breeding high-yielding strains. This will involve seed selection, cross pollination, grafting, and a study of heredity as it affects gum-yielding capacity.

Annual burning of the litter and ground cover as a fire prevention measure is a common practice among nearly all turpentine operators in the southern United States. This practice interferes seriously with the reproduction and growth of pines, besides paving the way for insect and fungus attacks. It is believed that lower yields of gum also result from these periodic fires. This, however, is another question which research must answer. It will necessitate a detailed study of fires, their action upon the fertility and moisture-holding capacity of the soil and upon all physiological processes of the tree, including the production of resin and growth of the tree itself.

Turpentining practices which have been in vogue for many years will doubtless continue until it can be proved that the adoption of more efficient methods will bring about lower unit production costs. Specific information concerning costs as related to average gum yields obtained from longleaf and slash pine trees of different sizes and ages and upon different sites, would be of inestimable value to the industry and can be supplied only through research. This economic problem is complicated by the fact that

about 75 per cent of the total naval stores production comes from timber that is leased by the owners to operators. These operators with but a temporary interest in the timber rarely look beyond the present operation.

It will also be advantageous to have a clearer understanding of the relation of turpentining practices to the formation, structure and the physiological processes involved in the production of gum in the tree and its removal from the tree. This necessitates microscopic studies of the structure and anatomy of the tree and analysis of the biochemical relations involved in gum production. This type of investigation is being handled by the Forest Products Laboratory of Madison, Wisconsin.

The insects and fungi which attack trees being worked for naval stores present many problems for the forest entomologist and pathologist. Improvements in the quality of the final products (turpentine and resin) and the development of new uses for these products, offer another particularly rich field for research.

The results of forest research work on naval stores problems which has been under way by the Southern Forest Experiment Station at Starke, Florida, since January, 1923, have been given out from time to time in the form of progress reports or through addresses delivered before gatherings of naval stores men. Formal reports which will be issued as government publications are now in process of preparation. A few of the results of preliminary tests may be summarized as follows:

1. Average gum yields increase with the diameter of the tree. The average yield obtained from trees under 9 inches in diameter is so small that under present conditions these small trees cannot be turpentined profitably. The working of small trees ruins them for future gum and wood production.

2. Trees of the same size and general outward appearance, growing under similar conditions of soil and climate and worked by the same methods, exhibit wide variations in yield. These differences in yielding capacity must be due to inherent differences in the trees themselves. This fact presents an opportunity for increasing yields by selecting high-yielding strains for propagation.

3. Conservative chipping practices result in increased yields of gum, a longer working life for the operation, a better rate of growth, and less damage from windfall, insects, and disease. The use of No. 0 hacks is advised. Width of streak (amount of wood removed in height at each chipping operation) should be held to ½ inch. Depth of streak (maximum distance cut into tree) should be approximately ½ inch and never over ¾ inch.

4. Open-grown trees yield more than the same sized trees in dense stands. Thinning out improves the yield as well as the health and vigor of the trees.

5. Average temperature has a decided effect on the flow of gum. In one instance the yield of gum doubled with an average increase in temperature of 15° F. Turpentining during the winter months is unprofitable unless the period between chippings is lengthened.

Adequate forest research on naval stores problems is one of the most important needs in the southern part of the United States, if this important industry is to be placed on a permanent basis

and the 70,000,000 acres of potential naval stores producing land are to yield a continuous revenue to the landowners. The permanence of many communities and the continued prosperity of that part of the United States depend on the harvesting of naval stores crops by methods which will insure the stability and perpetuation of this important basic industry. There is no doubt but that forest research must fill an important place in the development of the naval stores industry and in the economic development of the southern pine region as a whole.

TURPENTINING EXPERIMENTS WITH WESTERN YELLOW PINE IN NORTHERN CALIFORNIA[1]

By T. N. MIROV

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THE POSSIBILITY of turpentining western yellow pine (*Pinus ponderosa* Laws.) is likely to be a question of future importance in California. Its feasibility will depend in part on the future methods of handling southern pineries. But even now there are some indications that western yellow pine may become a profitable source of turpentine. It appears, therefore, that any experimental data bearing upon this subject may be of some value.

Historical

First attempts to obtain turpentine from California pines were made during the Civil War, but when the high prices of that period receded the war-time operations ceased (13). Nearly 50 years later interest in turpentining was renewed because of the prospect of rapid exhaustion of southern resources, and in 1910-1913 the United States Forest Service undertook experimental tapping in the Sierra National Forest in central California. At that time analyses of California turpentine were made by the Forest Products Laboratory at Madison, Wisconsin, and the quality of the product was found to compare favorably with that of the spirits of turpentine from the southern United States.

While the assurance of acceptable quality in turpentine from the western yellow pine makes the main question one of yield, there are still certain differences in composition, physical constants, and the like, between the turpentine from this species and that from the pines of the Southern States, and some indications of variations in the product within the former species as found in California, as indicated first by Schorger (12). In a recent paper (8) the present writer discussed some of these questions in connection with the taxonomic relation between *Pinus ponderosa* and the closely related *P. jeffreyi.* As a result of further work, stimulated by the interesting results of his previous venture, an attempt is made in the present paper both to add to the knowledge of the oleoresin and turpentine yields of *Pinus ponderosa,* and to extract from the same data some interesting indications of taxonomic heterogeneity within this species itself as found in California.

In 1928 the Bureau of Entomology undertook some chemical studies in insect control, upon which the writer was engaged. These studies offered him an opportunity to collect some additional data regarding the oleoresin yields of western yellow pine in northern Cali-

[1] Acknowledgment is made to Prof. Emanuel Fritz of the University of California and to Mr. C. L. Hill, in charge of forest products research at the California Forest Experiment Station, for criticism of this paper.

fornia. It is fully appreciated by the writer that the averaged data submitted are not extensive enough to yield entirely dependable results and that the period of tapping was rather short; nevertheless it is hoped that the results of this investigation may be of some value for those who are interested in the possibilities of western yellow pine as a source of naval stores.

Present Experiments

The experimental work in 1928 was done on an area in the very northeastern corner of California, in the vicinity of Buck Creek Ranger Station, Modoc National Forest. The area lies upon an independent ridge of the Warner Mountains, which there divides Surprise Valley from Goose Lake Valley and is covered by good stands of western yellow pine, with a certain intermixture of incense cedar (*Libocedrus decurrens*) and white fir (*Abies concolor*). Rather extensive stands of lodgepole pine (*Pinus contorta*) and scattered groves of western white pine (*P. monticola*) occupy plateaus of higher elevations.

The Buck Creek Ranger Station, where a weather station and a small field laboratory were established, is located on a gentle westerly slope of the Warner Ridge at an elevation of 5050 feet. The weather station is protected on the east side by the ridge, but is open on the west toward the extensive Goose Lake Valley. Temperature and relative humidity were recorded throughout the experimental season by means of a thermohygrograph housed in a Weather Bureau standard instrument shelter. The conditions of tree growth were checked with a dendrograph attached to a thrifty blackjack, or young western yellow pine. All these data are plotted on Plate 1.

The experimental season extended from the beginning of July to the middle of September. Originally, 100 trees were selected, but only 70 specimens were tapped regularly, once a week. One tree died in the middle of the season and was omitted from the calculations. Two cups were placed on each tree, therefore the number of cups recorded totalled 138.

Experimental trees were selected in three different localities, namely, the Sugar Hill, Buck Creek and Jerome Mill areas. A fourth area containing 30 trees (60 cups) was located at a considerable distance from the camp (about 70 miles), but was chipped only occasionally, for the collection of comparative oleoresin samples. All trees were numbered, tagged, and carefully described in regard to morphological, and often anatomical, characters (such as number of resin ducts in needles). A growth increment core was taken from each tree.

Detailed Description of Experimental Areas

Sugar Hill Area

The Sugar Hill area is located in the southeast ¼ of Section 10, T. 46 N., R. 14 E., M. D. M., at an elevation of 5400 feet. This area occupies a very gentle slope of northwestern exposure, being practically flat. The soil is derived from so-called Warner basalt and is well decomposed and fine. The stand is pure western yellow pine with just a few young firs and cedars intermixed, especially on the upper part of the area, and has a healthy appearance. The site class varies between two and three. Re-

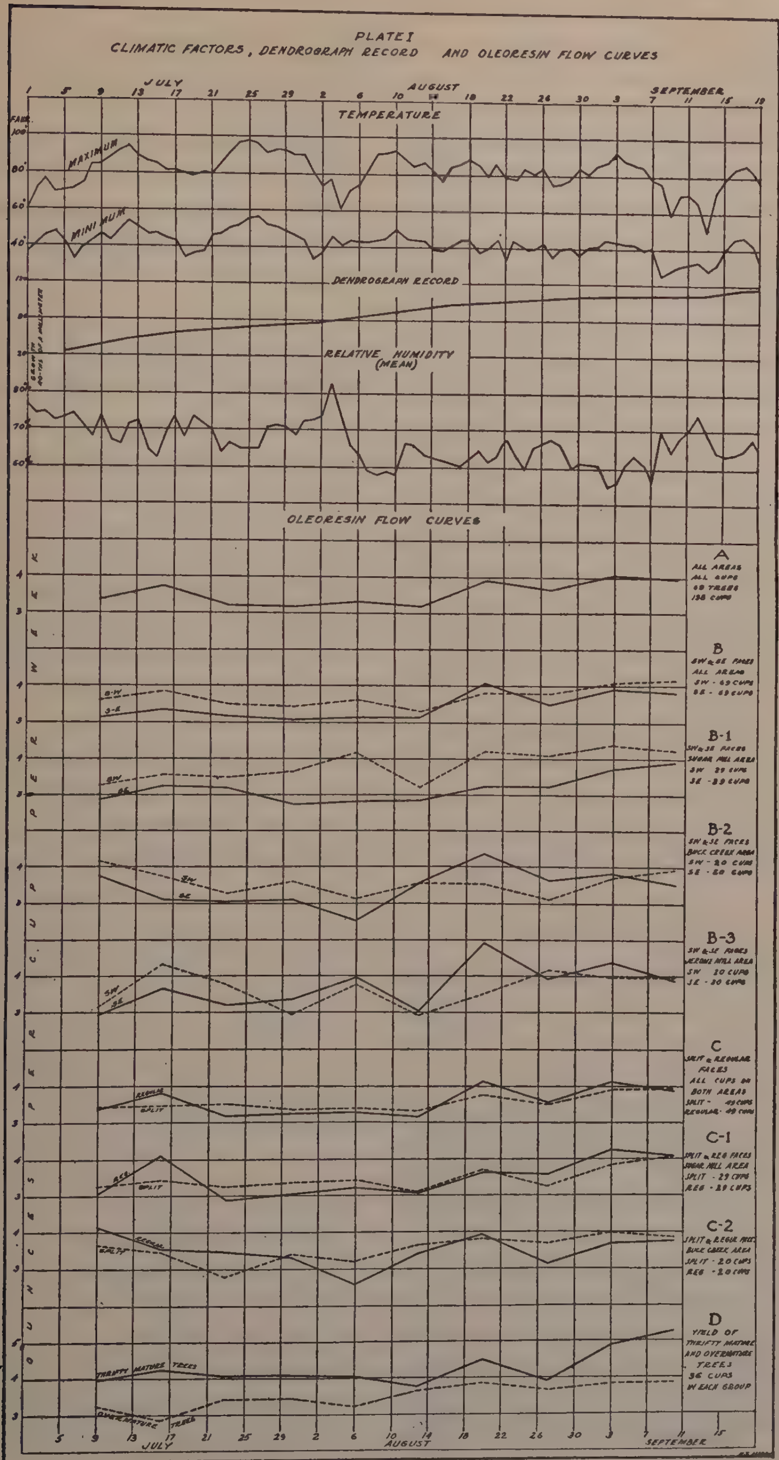


PLATE I
CLIMATIC FACTORS, DENDROGRAPH RECORD AND OLEORESIN FLOW CURVES
JULY
AUGUST
SEPTEMBER
TEMPERATURE
MAXIMUM
MINIMUM
DENDROGRAPH RECORD
RELATIVE HUMIDITY (MEAN)
OLEORESIN FLOW CURVES
A
ALL AREAS
ALL CUPS
B
SW & SE FACES
ALL AREAS
B-1
SW & SE FACES
SUGAR HILL AREA
B-2
SW & SE FACES
BUCK CREEK AREA
SW - 20 CUPS
SE - 20 CUPS
B-3
SW & SE FACES
SW 20 CUPS
SE - 20 CUPS
C
SPLIT & REGULAR FACES
ALL CUPS ON BOTH AREAS
C-1
SPLIT & REG. FACES
SUGAR HILL AREA
C-2
BUCK CREEK AREA
SPLIT - 20 CUPS
REG - 20 CUPS
D
YIELD OF THRIFTY MATURE AND OVERMATURE TREES
36 CUPS IN EACH GROUP
THRIFTY MATURE TREES
OVERMATURE TREES

producton is not very abundant and is usually found in patches. Underbrush is represented by a few specimens of *Lonicera* sp. and *Purshia tridentata*. Herbaceous vegetation is very scarce as a rule and is composed of *Lupinus, Whyethia,* and some *Gramineæ*. *Ceanothus prostratus* is also present. In respect to bark-beetle attacks, the 1927 *Dendroctonus brevicomis* infestation in this area was estimated to include about 5 per cent of the stand. The 1928 infestation showed a marked decline to about 1 per cent.

Thirty trees were selected in this area with diameters varying from 24 inches to 43 inches (average 27.7 inches). The average number of annual rings in the last inch was 48. A few trees were attacked by *D. valens* soon after the first turpentining scar was made. In the case of one tree (No. 18) the attack of this beetle was rather severe; later this tree was also attacked by *D. brevicomis* and killed before an amount of oleoresin sufficient for analysis was collected.

BUCK CREEK AREA

The Buck Creek area is located about half a mile east of the ranger station in Section 5 (unsurveyed), T. 46 N., R. 15 E., M. D. M. The elevation is 5500 feet. The area occupies a fairly steep slope of southwestern exposure and is rocky in places. The stand is almost entirely composed of western yellow pine, with an intermixture of a few old incense cedars. Reproduction is in patches, sometimes very abundant. The presence of *Cercocarpus ledifolius* is quite characteristic of this area. The herbaceous vegetation is almost identical with that of the Sugar Hill area. About 3 per cent of the stand was killed by *D. brevicomis* in 1927 and probably 1 per cent in 1928.

Twenty trees were selected on this area for experimental purposes, with an average diameter of 30.9 inches. The average number of rings in the last inch was 37.8.

JEROME MILL AREA

This area is located about one mile north of the old Jerome Mill in the northwest quarter of the northwest quarter of Section 32, T. 46 N., R. 15 E., M. D. M. It has an elevation of 5800 feet, occupies a gentle northerly slope, and is characterized by a heavier admixture of both incense cedar and white fir with the western yellow pine than in the preceding areas, with abundant reproduction of these two species. Western yellow pine trees are generally overmature, although apparently healthy. The site is between two and three. Beetle infestation for 1927 was found to be below 1 per cent. Reproduction is fair. Herbaceous vegetation is similar to that of the other areas except that *Whyethia* is absent.

Twenty trees were selected in this area with an average diameter of 37.0 inches, the average number of rings in the last inch being 32.8.

SUMMARY

Table 1 summarizes these data for the three experimental areas. The Jerome Mill area showed the best rate of growth and the highest yield of oleoresin. The Sugar Hill area, on the contrary, had the smallest growth rate and the lowest oleoresin yield.

TABLE 1

COMPARATIVE DATA FOR THE THREE EXPERIMENTAL AREAS

Name of area	Number of experimental trees	Silvical characterisitcs	Elevation Feet	Average diameter Inches	Average number of rings in last inch	Yield per cup per week Ounces
Sugar Hill	30	Pure western yellow pine.	5400	29.7	47.8	3.425
Buck Creek ...	20	Admixture of incense cedar.	5500	30.9	37.8	3.485
Jerome Mill ..	20	Admixture of white fir and incense cedar.	5800	37.0	32.8	3.666

DESCRIPTION OF EXPERIMENTAL TREES

Table 2 shows the number of experimental trees by experimental areas and by tree classes according to Dunning's classification (3). It is evident from this table that the diameters of the experimental trees vary within large limits and that the greater part of the trees are overmature, belonging to class 5. The number of mature trees, classes 3 and 4, is much smaller than that of the overmature class 5.

TABLE 2

NUMBER OF EXPERIMENTAL TREES BY EXPERIMENTAL AREAS AND TREE CLASSES

D. B. H. Inches	Sugar Hill				Buck Creek				Jerome Mill				All areas			
	Number of trees by tree classes															
	3	4	5	Total	3	4	5	Total	3	4	5	Total	3	4	5	Total
24	0	1	3	4	1	0	0	1	0	0	0	0	1	1	3	5
26	1	0	0	1	0	1	0	1	0	0	0	0	1	1	0	2
28	4	1	2	7	0	2	1	3	0	1	0	1	4	4	3	11
30	0	0	3	3	1	0	1	2	0	0	1	1	1	0	5	6
32	0	0	5	5	1	0	3	4	0	0	4	4	1	0	12	13
34	0	0	4	4	1	0	3	4	0	0	4	4	1	0	11	12
36	1	0	3	4	1	0	1	2	0	0	4	4	2	0	8	10
38	0	0	0	0	0	0	2	2	0	1	1	2	0	1	3	4
40	0	0	1	1	0	0	1	1	0	0	1	1	0	0	3	3
42	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	2
43	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
52									0	0	1	1	0	0	1	1
Total ..	6	2	22	30	5	3	12	20	0	2	18	20	11	7	52	70

Implements and Methods

The first step in the preparation of the trees for turpentining was the removal of the outer bark, which in some cases was as much as 5 inches thick.

The aprons used were of a type devised by the writer in connection with previous tapping experiments upon Jeffrey pine for heptane. These are similar to the standard concave aprons, but instead of being inserted into a cut made with a broad axe, they are attached with three tacks to the surface of a groove cut in the thinned bark. This type of apron was found to be very advantageous for experimental tapping, as it does not require cutting through the cambium and thus does not disturb the tissues of the tree. It is very important in experimental tapping that all injuries or woundings, other than the direct chipping scars, be avoided if a normal response by the tree is to be expected. Another point in favor of this apron is that it can be easily attached by one man.

In the place of rectangular receptacles, friction-top pint cans were used. These, when placed on the tree, were protected from the heat of the sun by pieces of bark, and weekly oleoresin weighings were made without dipping. Of course the cans were changed as soon as they became filled. It was found that losses due to evaporation were much less than those which occur when weekly dippings are practiced.

The use of the friction-top pint cans was justified by the particular purpose of investigation, especially because it was intended to keep the oleoresin from each tree separate for the study of individual variation in oleoresin composition. Cups were set much higher than in regular commercial practice. Chipping was performed with both No. 2 and No. 00 turpentining hacks, and also with a No. 00 mounted into an 18-inch length of $1\frac{1}{2}$-inch steel pipe. This latter type was found to be especially good for large, overmature trees with rough thick bark.

Experimental chippings consisted of the following:

Number of cups per tree—two in all cases.

Width of face—10 inches.

Height of streak—$\frac{1}{4}$ inch to $\frac{3}{8}$ inch.

Depth of steak—$\frac{1}{4}$ inch to $\frac{3}{8}$ inch.

Number of streaks per week—one.

Period—10 consecutive weeks.

Yields of Products

Yield of Oleoresin

The average yield of the experimental trees per cup per week, based on 138 cups, is shown in Table 3 with data from previous experiments in California and Arizona (2) for comparison. The Arizona experiments were continued from the beginning of May to the end of October. The Sierra National Forest experiments were started in July and completed in September. The writer's experiments covered the same period of time. The higher yield of the Sierra experiments may be explained by the lower latitude and altitude, the latter being 1000 feet less than in the case of the Modoc experiments.

It is of interest to note that the oleoresin yield found by the writer in the Lassen National Forest (adjoining the Modoc National Forest) in 1927 for Jeffrey pine, was almost the same (0.220 pounds) as for western yellow

pine in the present experiments. This appears to be in contradiction to the generally accepted idea that western yellow pine yields more oleoresin than Jeffrey pine.

It should be noted that a certain period of time is required for trees to respond to a change of temperature. The temperature curve during August indicates very warm weather in that month with a decrease at the beginning of September. Corresponding to this, the yield curves show a marked increase during the month of August. In the last half of September yield probably would drop considerably.

The dendrograph record shows a steady increase in growth rate from the beginning to the end of the season, and it is readily seen that there is a well-marked correlation between the physiological activity of the tree and oleoresin production.

TABLE 3

COMPARATIVE YIELD OF OLEORESIN IN ARIZONA, CENTRAL CALIFORNIA, AND NORTHERN CALIFORNIA

Locality of experimental area	Year	Elevation Feet	Yield per cup per week Pounds
Arizona (Tusayan and Coconino National Forests)	1911	7300–7600	0.217
Central California (Sierra National Forest)....	1911	3500–4500	0.281
Northern California (Modoc National Forest)..	1928	5400–5800	0.220

YIELD OF VOLATILE OIL (TURPENTINE)

According to data of the Forest Products Laboratory (9) the 1911 oleoresin samples from the Sierra National Forest yielded 17.75 per cent of turpentine. In the present tests, made in the field laboratory, the following yields of turpentine were obtained:

Tree no.	Per cent
28	13.6
33	13.3 (July sample)
33	13.2 (August sample)
76	13.0
64	13.6

Factors Affecting Oleoresin Flow

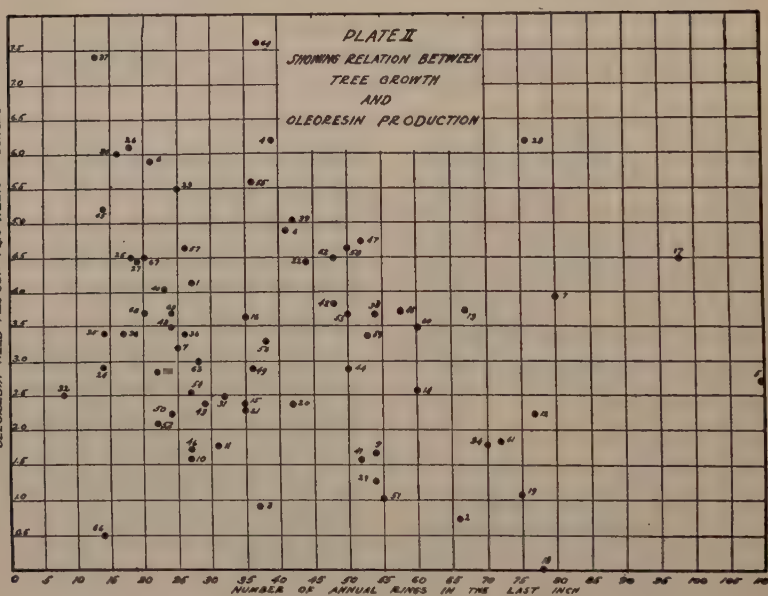
Temperature and relative humidity records (Plate I) show that a very uniform climatic condition prevailed throughout the experimental season. Only once (August 4) was there a marked decrease in the maximum temperature curve with corresponding increase in relative humidity. The cold spell occurring at that time influenced the oleoresin flow, and in all yield curves there appears a decrease for August 13.

Individual Variation in Oleoresin Production

The variation between individual trees in ability to yield oleoresin is a very important factor in the average yield calculations, as it tends to conceal both the true meaning of the chipping method used and the influence of various climatic factors. This is especially noticeable when a small number of trees is taken for experimental purposes.

On Plate 2 all seventy experimental trees are plotted. The abscissæ show

the number of annual rings in the last inch; the ordinates, the average yield per cup per week (mean for the two cups). Study of this plate shows that there is a general decrease in yield with decrease in growth rate, but at the same time it may be noticed that the best-producing trees are not necessarily found among the fastest-growing trees. Specimens classed among slow-growing trees may yield as much as the fastest growers; also, two



trees of the same diameter and age class and of the same rate of growth may differ markedly in oleoresin production.

On the supposition that present growth is more important for oleoresin production than that of past years, Table 4 was prepared in order to compare the width of the last annual ring and the corresponding yield for all trees on the Sugar Hill area. Here, again, the general tendency to decreasing yield is seen, but variation in the individual oleoresin producing power is clearly evident and makes it difficult to correlate the growth rate with yield.

Experimental Tapping Variables

The tapping variables included exposure of faces; split versus regular faces; and mature versus overmature trees.

Two cups were placed on each experimental tree: one on the southwest side, another on the southeast. Ninety faces were of the standard form, the remaining 50 being "split faces" (this term is explained later). It appeared to be desirable to distinguish between mature and overmature trees; therefore, it has been tried to emphasize this item.

The oleoresin yield was calculated for all three areas separately, as their enviromental conditions differ to a certain extent.

The weakest point in respect to the tapping variables is the small number of trees in each group, but the principal

TABLE 4

COMPARISON OF WIDTH OF LAST RING AND YIELD OF OLEORESIN PER WEEK FOR ALL TREES ON SUGAR HILL AREA

No. of tree	Width of last ring Millimeters	Yield per week Ounces
26	2.45	2.90
24	1.36	6.15
8	1.17	5.90
25	1.02	4.50
27	.85	4.45
23	.69	5.50
1	.67	4.15
10	.61	1.60
6	.61	4.90
30	.55	3.75
22	.54	4.40
4	.46	6.20
3	.45	0.95
16	.40	3.65
21	.38	2.30
9	.35	1.70
29	.33	1.30
11	.30	1.80
13	.28	3.75
28	.25	6.20
12	.24	2.75
2	.24	0.75
20	.24	2.40
14	.21	2.60
7	.20	3.95
18	.20	0.0
15	.18	2.4
17	.16	4.50
19	.15	1.10
5	.15	2.70

purpose of the Modoc tapping experiments for the entomological studies did not permit as large groups as would undoubtedly have been desirable, and the present study is dealing with the rather limited material available.

EXPOSURE OF FACES

The yield from the southwest faces (69 cups) was 3.69 ounces per cup per week; that from the southeast faces (also 69 cups) was 3.42 ounces. The higher yield of the southwest faces may be observed in Plate 1, " B," with only one inconsistent point (July 20), when the generally warmer weather supplemented on the southeast faces the beneficial action of direct sunshine which as a rule is stronger on the southwest sector of the tree trunk. The higher yield of the southwest faces is well shown in the case of the Sugar Hill area where the country is flat and unobstructed. In this case, southwest faces yielded 3.73 ounces per cup per week, and southeast faces 3.12 ounces. (Graph B-1.) It is less noticeable in the case of the Buck Creek area (westerly exposure), the yield being 3.60 ounces for the southwest faces, and 3.37 ounces for southeast faces. (Graph B-2, 20 cups in each group.)

On the Jerome Mill area, located on the northern slope, where direct sunshine plays but a small rôle, the yield data are reversed: southeast faces produced 3.73 ounces per cup per week, and southwest faces 3.60 ounces or slightly less. The number of cups in each group was 20.

It appears, therefore, that the sector of a tree from south to west is the most favorable for oleoresin production, especially when tapped trees are exposed to direct sunlight. On the other hand, the scarification of trees on the southern side should be avoided as much as possible according to some operators (4), since it decreases the physiological activities of the tree.

In the author's previous experience with the tapping of Jeffrey pine in the Lassen National Forest, it was found that it does not pay at all to set cups on the north side of trees.

SPLIT VERSUS REGULAR FACES

The split face method recently developed in southern pineries appears to be a promising improvement. Essentially, this method consists in leaving a strip of bark between the two halves of a face. This strip should be of the same width as the scars on both sides of it. In the present instance, however, the equipment and the requirements for the principal purpose of the study (entomological) did not permit the leaving of a strip more than 2 inches wide, although the two sides of the face were about 10 inches. Average yields per cup per week were as follows (See also Plate 1, C, C-1, C-2):

	Ounces
Regular faces (49 cups)....	3.58
Split faces (49 cups).......	3.56

In other words, no significant difference of yield was obtained, both types of face yielding practically the same amount of oleoresin. It appears, however, that even a 2-inch strip of untouched bark between the two parts of a face will consistently assist in the healing of the scars.

The author also tried the split-face method in the Lassen National Forest while assisting in the 1928 tapping of Jeffrey pine for heptane, continued by the California Forest Experiment Station. In this case the strip of bark left was 8 inches wide and the results were unexpectedly good. In fact, the split faces yielded 70 per cent more oleoresin than the regular faces of the same size. This was probably due to the greater width of the strip of bark left. At any rate it makes it desirable to check on this variable again.

YIELD OF MATURE VERSUS OVERMATURE TREES

As previously stated, nearly 75 per cent of the experimental trees are overmature, belonging to class 5 according to Dunning's classification (3). For yield comparison, 18 mature trees (classes 3-4) were paired as closely as possible with the same number of overmature trees (class 5). The average diameter of the former was 29.4 inches, and of the latter 31.2 inches. The average yield of both groups per cup per week, with 36 cups in each group, was as follows (see also Plate 1-D):

	Ounces
Mature trees	4.14
Overmature trees	3.46

Owing to the small number of trees in the groups, the graphs have a rather "jumpy" appearance; nevertheless, this variable proved to be quite interesting.

Unfortunately the purposes of the Modoc experiments did not permit obtaining any yield data for tree classes 1 and 2. However, in the Jeffrey pine experiments in 1927 it was found that "blackjacks" (thrifty young trees of classes 1 and 2) yielded less oleoresin than older trees (classes 3, 4 and 5). This, taken in connection with the present evidence, makes it appear that in these western yellow pines perhaps the best yielding trees are not necessarily found in the young trees of class 1, as in southern pines, but possibly somewhere at the middle of the class scale, as Mr. Dunning in a personal communication has suggested.

Variation in Oleoresin Composition

Owing to lack of time, only ten samples of oleoresin have been examined, and these only for the determination of

their physical constants: index of refraction and optical rotation. The results of this examination are given in Table 5, Schorger's (12) data being also given for comparison.

The data from northern California are in accord with Schorger's findings in regard to very extensive variations of western yellow pine oleoresin composition. The presence of two trees out of ten having dextro-rotatory turpentine supports Schorger's supposition that the dextro-rotatory Rocky Mountain form may occasionally be found in typical stands of the lævo-rotatory Pacific Coast form. The wide range in optical rotation (from +19.6 to −60.5) is another interesting feature of the table.

In the presence of such variation in physical characters it might also be expected that the chemical composition of turpentine from different trees would vary. Sample from tree No. 4 very closely resembles Schorger's sample taken from the "limonene pine" from California. Tree No. 4 is by no means typical in appearance. Its bark is very smooth, purplish-brown in color and resembles the bark of sugar pine in texture. Several similar specimens have been found among the experimental trees.

It would be highly desirable to enlist the interest of the Forest Products Laboratory for the verification and further extension of these analyses.

TABLE 5

COMPARISON OF PHYSICAL CONSTANTS IN DIFFERENT TREES AND LOCALITIES

Present Examination				Schorger's data			
Tree No.	Morphological classification of trees	Refraction index 15° C.	Optical rotation	Description of samples	Refraction index 15° C.	Optical rotation	Principal constituent
2	Typical	1.4755	+19.6	"Bastard Pine" from California.	1.4724	+30.33	Alpha-pinene
4	Non-typical .	1.473	—60.5	*P. ponderosa scopulorum* from Arizona.	1.4723	+13.03	Alpha-pinene
8	Non-typical .	1.4770	—13.5	Same	1.4729	+12.86	Alpha-pinene
22	Non-typical .	1.4760	—13.0	Non-typical *P. ponderosa* from California.	1.4765	—67.37	Limonene
29	Typical	1.4775	—59.0		1.4770	—27.14	Beta-pinene
36	Typical	1.4750	—21.5		1.4765	—18.44	Beta-pinene
37	Non-typical .	1.4760	— 4.0		1.4733	—12.63	Beta-pinene
59	Typical	1.4760	—23.3	Typical *P. ponderosa* from California.	1.4793	—21.23	Beta-pinene
72	Non-typical .	1.4757	+16.0		1.4785	—17.12	Beta-pinene
77	Typical	1.4770	—38.5		1.4780	—15.73	Beta-pinene

SUMMARY

In the experiments here reported, the experimental trees were selected in three different localities and most of them were overmature, the remainder being mature.

A slight departure from conventional methods of turpentining was made on account of the special purpose of the investigation.

The yield of oleoresin was found to be slightly less than in former (1911) experiments in central California but slightly higher than in Arizona tappings of the same date.

The yield of turpentine in northeastern California is much smaller than that in central California.

Individual variations in oleoresin production played quite an important rôle, and tend to conceal both the true meaning of the chipping methods and the influence of climatic factors. In the study of tapping variables, it was found that the southwest quadrant of a tree yields more oleoresin than the southeast one when the trees are exposed to direct sunshine, but not necessarily so when protected from the sun by exposure or otherwise.

An attempt to find a difference in yield between "split" and regular faces did not give positive results, although there is a good indication that the "split face" method may be worth consideration in future practice.

Comparison of yields of mature and overmature trees showed the former to yield much more oleoresin than the latter.

Preliminary analyses of oleoresin samples collected separately from different specimens showed that the composition of turpentine varies to a great extent, and indicate the probable presence with the type form *P. ponderosa* in California of the variety *scopulorum,* of the Rocky Mountains. The further extension of analyses is highly desirable.

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WOOD FIBERS

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THE physical and chemical properties of wood render it a satisfactory structural material. On account of the number of these properties that originate in the fiber units, it seemed desirable to make an extensive study of the microstructure of the wood fiber and its attendant properties. The results herein described were obtained from an examination of the major cell units of the tree, namely, the fibers of hardwoods and the tracheids of softwoods.

A living tree may be considered a colony of fibers, orderly in their arrangement and divided into groups. Each group performs definite functions, which are both dependent on life and are necessary for the well-being of the tree. Wood taken from a tree is of the same unit cell structure as the living tree, but the motivating force (life) is absent, and hence the cells cease to function as far as the life processes are concerned. Also, with the passing of life the cells modify their physical and chemical properties. Therefore, the results obtained from a study of the physical and the chemical properties of wood may be in serious error when an attempt is made to apply them to what appear to be comparable conditions in the living tree. If the difference in conditions caused by life is kept in mind, however, it is quite possible that valuable information may be obtained from a study of fibers; and may assist in the interpretation of phenomena observed in larger wood members and in living trees.

In research studies dealing with trees or sections of wood it is convenient to consider wood fibers as unit cells, because they are integral units from the point of view of plant anatomy and plant physiology.

In the study now reported whole fibers in the delignified form were isolated from shavings that had been cut from green wood by means of a plane; sections of fibers were taken from thin cross sections of green wood.

The results presented here, selected from the results for the 16 species investigated thus far, cover representative species. They may be conveniently grouped for presentation under the heads that follow.

LIGNIN

Lignin is one of the major constituents of wood. According to the Forest Products Laboratory's methods of analysis, lignin forms from 18 to 25 per cent of the total wood substance of hardwoods and from 22 to 28 per cent of the wood substance of softwoods. A few exceptions to these values have been found in isolated cases in which the lignin content is over 30 per cent.

Considerable work has been done by Ritter[2] and Harlow[3] on the location of

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Ritter. Ind. Eng. Chem. 17:1194 (1925).

[3] Harlow. New York State College of Forestry, Tech. Pub. No. 14, July, 1928.

lignin in the cell walls of wood fibers. According to Ritter two forms of lignin appear in the cell wall; one form, found in the middle lamella, acts as the binding material between the wood cells that compose the vertical and the horizontal wood elements, while the other form, found in the cell wall, is closely associated with the cellulose. Whether the association of the second form of lignin and cellulose is physical or chemical is not known.

According to Ritter, the first form is named "middle-lamella lignin" and the second "cell-wall lignin." Further, according to the same writer, the middle-lamella lignin is isolated in the form of thin-walled and pointed capsules that envelop the wood fibers, which in turn are lignified with the cell-wall lignin. In addition, the cell-wall lignin is isolated in the form of a finely divided amorphous material, which agglomerates into clusters within the capsule of middle-lamella lignin. (Fig. 1.)

By a careful technic it is possible to obtain a fair degree of separation of the two forms of lignin. Figure 2 is a photomicrograph of a cross section of middle-lamella lignin of western yellow pine, which has been impregnated with paraffin to keep the thin walls in a vertical position.

Harlow agrees with Ritter in stating that the middle lamella of mature woods is lignin, but he asserts that with hardwoods the cell wall contains no lignin except in cells having a tertiary layer, and that the tertiary layer only is lignified. He maintains that the cell wall residue described by Ritter can be explained on the basis of residual cellulose rather than lignin. The residue dissolves on chlorination and treatment with sodium sulfite solution, however, which is characteristic of lignin and not of cellulose.

With softwoods, Harlow's observations confirm those of Ritter in that the cell wall is lignified. Harlow, however, states that, where the cell-wall lignin is isolated, the form of this lignin is that of the general contour of the cell wall rather than a finely divided amorphous substance as described by Ritter. This is a minor difference in the results that may be due to some specific properties of the samples, which in turn may have affected the degree to which the cellulose was dissolved by Harlow. This is only a suggestion, since the character of the samples was such that he made no other qualitative or quantitative test for lignin on the residue and for that reason the cause of the difference is not definitely apparent.

Chemically, lignin consists of approximately 63 per cent carbon, 6 per cent hydrogen, and 31 per cent oxygen.

The writer appreciates the basis for the botanists' pectin conception of the middle lamella. That conception is perhaps correct for succulent plant tissues, but not for mature woods, because the middle lamella of mature woods has neither the solution properties nor the chemical properties of pectin, as the following facts show:

1. Various forms of pectin are soluble in the following solvents: Cold water, hot water, dilute alkali, sucrose solution, and ammonium oxalate. None of these solvents will dissolve the middle lamella of mature woods.

2. Pectin has a methoxyl content of 8 to 9 per cent. The middle lamella of mature woods has a methoxyl content of 13 to 14 per cent.

3. Making the calculation from the generally accepted formula, pectin will form furfural approximating 40 per cent of the weight of the pectin when it is heated in boiling 12 per cent hydrochloric acid. The middle lamella of mature wood forms no furfural when heated in boiling hydrochloric acid.

STRUCTURE OF WOOD FIBERS

The cellulose remaining after the extractives and the lignin have been dissolved from the wood has a complicated structure that gives strength to the fibers. Certain phases of this structure were predicted from the optical phenomena manifested by the fibers, but the actual demonstration of such a structure was lacking until a dissection of the fibers had been accomplished. In separating the building units in the cell wall of the fibers, it was necessary to cut in natural planes of cleavage. On account of the minute thickness of the cut, it became necessary also to dissect by means of chemicals, namely, sodium hydroxide, and phosphoric and sulfuric acids.

LAYERS

With the aid of sodium hydroxide, phosphoric acid, and sulfuric acid, it is possible to demonstrate that the cell wall of wood fibers is composed of several thin layers and that those layers may be loosened from one another as shown in the photomicrograph of Figure 3. A fiber disintegrated to the stage illustrated, however, will still resist separation of its layers, because the layers are concentric and pointed and their shape prevents the slipping endwise of any single one. Yet by cutting short sections from such a partially disintegrated fiber, so as to obtain parts with open ends (concentric tubes), it is possible to actually separate the layers. (Fig. 4.)

Since results obtained from some swelling tests suggested that the structure of the outer layer differs from that of the inner layers (Fig. 5), the next step in the dissection was made in order to determine the difference in the minute structural design of the various cell wall layers.

Outer Layer. Except for the pits the outer layer appears under the microscope as a smooth continuous sheet. Upon treatment of the fiber with phosphoric or sulfuric acid of the proper concentration, the outer layer develops striations at right angles to the long axis of the fiber; these striations give the fiber an appearance similar to that obtained by winding a string around a pencil in a continuous layer. The outer layer of the fiber is actually composed of tiny thread-like structures (fibrils) which may be unwound, and if the treatment with acid is continued under the proper conditions, this fact will become evident. When this layer has been dissolved, an extreme transverse swelling of the remaining cell wall occurs. (Fig. 6.) Such a contrast in the behavior of the two kinds of cell-wall layers strongly suggests a difference in structure.

Inner Layers. There are several inner layers enclosed within the outer layer just described. As many as seven have been observed in some of the thick-walled fibers. Since the swelling properties and also the optical properties of the fibers suggest an orientation of the fibrils in the inner layers distinctly different from that of the outer layer, it was decided to demonstrate the difference by separating the fibrils.

FIBRILS

To accomplish a dissection of a wood fiber that will show the inner layers of fibrils, the concentration of the acid used is lowered and the temperature is elevated so as to produce a partial hydrolysis rather than only a solution of the carbohydrate material in the fibers. With such treatment a striation of the inner layers develops, showing the spacings between the fibrils. These spacings indicate that, in general, the fibrils of the inner layers are oriented between zero degrees and 30 degrees to the long axis of the wood fiber, and that the orientation may vary in adjoining layers. (Fig. 7.) With careful handling the loosened fibrils will retain the general shape of the wood fiber (Fig. 8), but on allowing the action of the acid to continue the fibrils become isolated as shown in Figure 9.

FUSIFORM BODIES

An examination of the fibrils with the aid of a high-power microscope indicated that the fibrils were composed of smaller visible units. By changing the concentration of the acid and temperature it was possible to separate the tiny spindle-like units of which the fibrils are composed. (Fig. 10.) These units grow with a slight overlapping of the pointed ends similar to that of the fibers in the tree.

There is some evidence that the fusiform bodies, the fibrils, and the layers are held together by a carbohydrate cementing substance. Through a partial hydrolysis, the material is dissolved, and consequently the spacings between the various building units are increased until their magnitude is such as to come within the resolving power of the microscope. The spacings become more visible also on account of the difference in the indexes of refraction of the building units and of the aqueous solution that enters the spaces previously occupied by the cementing material.

Swelling Properties

Since wood is composed mainly of fibers, it is only natural that many of its properties originate in the fibers. If the properties of the individual fibers are assumed to be more simple than those of wood, it will be reasonable to start with a consideration of the properties of isolated fibers and then proceed toward the wood in logical steps in order to understand better the more complicated resultant forces that must be considered in a study of the swelling of such materials as wood, paper sheets, wall board, and artificial silks. In working with individual delignified fibers, it is not only more nearly possible to measure directly the internal as well as the external swelling than with wood, but also it is fully possible to determine the effect of the extractives and the lignin on the swelling. Only qualitative results obtained from a preliminary study of both lignified and delignified wood fibers are recorded in this article. The study is being extended to the quantitative stage and will include the three-dimensional linear swelling and the total volume swelling of delignified fibers.

Delignified wood fibers on swelling not only increase their external dimensions, but they also decrease the volumes of the lumens. There is, therefore, both external and internal swelling of such fibers. If a collection of closely packed fibers such as a sheet of pulp is treated with a swelling agent, external and internal swelling of the cell walls of the

individual fibers occurs, and in addition there is another source of swelling, which adds to the external over-all dimensions of the sheet. This last source of swelling is manifested through a pushing apart of the fibers by a film of the aqueous swelling agent.

On treatment with swelling agents delignified fibers tend to modify their shape, besides swelling. After their removal from the cementing material of the wood, their cross section tends to change from an angular to a circular form when treated with aqueous swelling agents. In water, that tendency is strong; in dilute alkalis, it is even more exaggerated. (Fig. 11.)

According to Ritter[4] the cell walls of lignified fibers in wood sections, as well as those of delignified isolated fibers, swell both inwardly and outwardly. The cementing material between the fibers in such a section swells also. This source of swelling, the magnitude of which is limited chiefly by the swelling properties of the cementing material with respect to a given swelling agent, tends to increase the external dimensions of the wood section. When this source of swelling is calculated on the basis of the unswollen substance in which it occurs, it is of considerable magnitude.

On account of the restraint both of the cementing material between fibers and the other fibers themselves, lignified fibers in wood sections retain their rectangular cross-sectional shapes on swelling, thus contrasting with the circular cross-sectional shape assumed by isolated fibers. (Fig. 12.)

[4] Ritter. Ind. Eng. Chem. 20:941 (1928).

Optical Properties

Wood fibers exhibit some specific optical properties in polarized light. Since the fibers are composed of several constituents and many physical building units, it is of interest to study the specific optical properties of those constituents in order to see which of them give the complex wood fibers their predominating influence on light under definite conditions.

In general, the fibers are composed of cellulose, lignin, and extractives (ether and water soluble). If a lignified wood fiber with no previous chemical treatment is examined between Nicol prisms that are oriented at 90 degrees to each other, the following phenomena will be observed: (1) If the long axis of the fiber is parallel or perpendicular to the long axis of either prism, the fiber will be scarcely visible; (2) if the fiber is oriented at 45 degrees to the prisms, the maximum luminosity of the fibers will be obtained; (3) if the fiber is oriented at any other angle to the prisms a degree of luminosity intermediate between the minimum and the maximum will obtain.

Extractives that have crystallized from liquids in the wood fibers modify the effects that are due to the optical properties of the fibers in polarized light. Such crystalline extractives modify the effect of the optical properties manifested by the remainder of the fibers in three ways: (1) They exhibit their own characteristic optical properties, which are additive to those of the fiber itself; (2) they impart a color shade that is similar to the color of the extractives in ordinary light; and (3) they reduce the intensity of the luminosity by increasing the density of the medium through which the light passes. *Extractives in a solid amorphous*

FIG. 1.—The middle lamella lignin and the cell wall lignin of red alder. 900 ×.

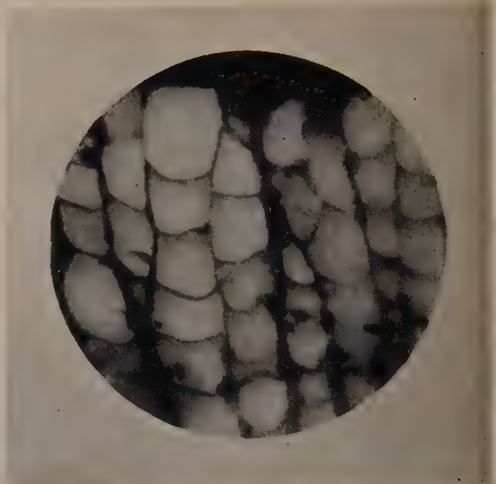

FIG. 2.—The middle lamella lignin of western yellow pine with its cavities impregnated with paraffin. 800 ×.

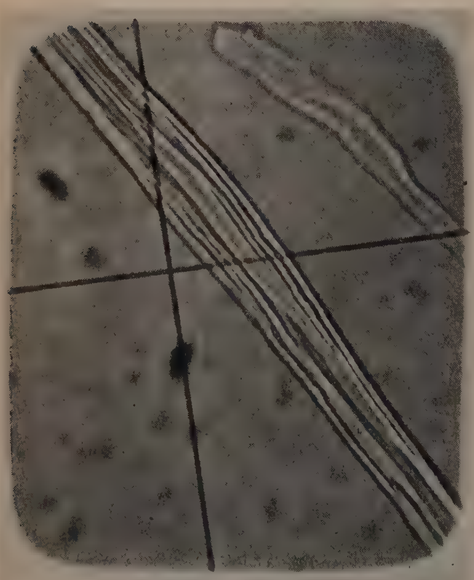

FIG. 3.—A delignified elm fiber, the cell wall layers of which have been loosened. 1000 ×.

FIG. 4.—Short sections of delignified elm fibers in which the cell wall layers have been loosened and slipped endwise. 600 ×.

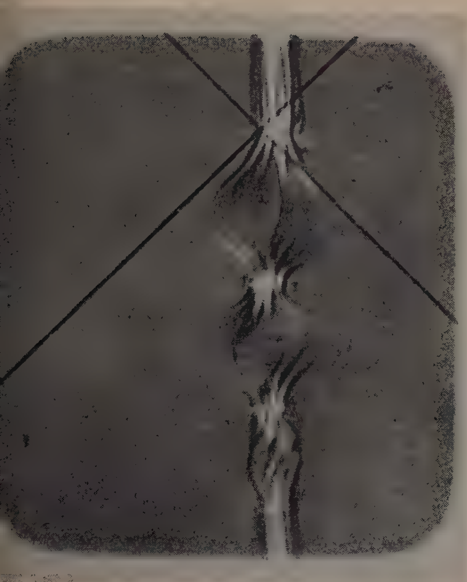

FIG. 5.—The outer layer of the cell wall is tact at the constricted places. It has been dis-lved at the swollen portions. 1000 ×.

FIG. 6.—Windings of the fibrils of the outer layer of a loblolly pine fiber, and extreme transverse swelling of the inner layers from which the outer layer has been dissolved. 800 ×.

G. 7.—Partially loosened fibrils of the inner layers of an elm fiber. 800 ×.

FIG. 8.—Fibrils of white pine well loosened but still retaining the general shape of the fiber. 800 ×.

FIG. 9.—Isolated elm fibrils with larger sections of elm fibers. 800 ×.

FIG. 10.—Fusiform bodies from elm fibers. 1000 ×.

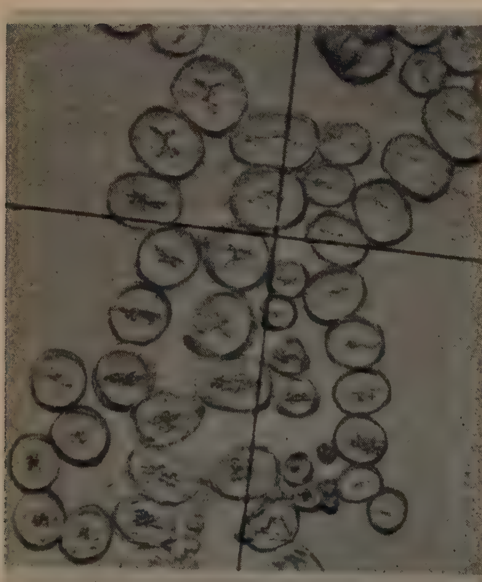

FIG. 11.—Cross section of isolated delignified fibers of western yellow pine swollen with sodium hydroxide solution. 500 ×.

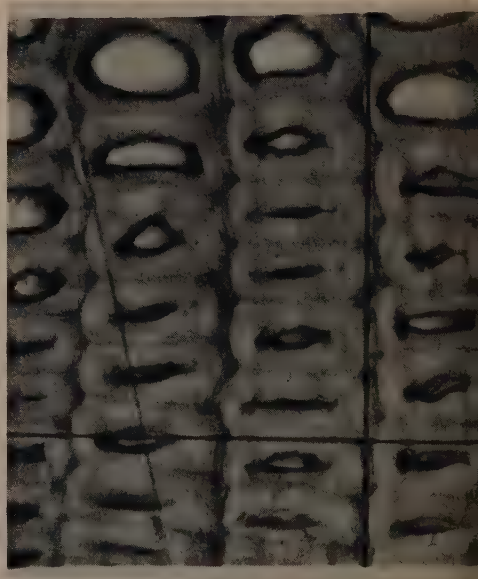

FIG. 12.—Cross section of western yellow pi[ne] that has been treated with sodium hydroxi[de] solution. It shows swelling of the cementin[g] material and the cell wall with a retention [of] the polygonal shape of the cells. 700 ×.

state or in solution in the liquids of the fiber modify the optical effects (2) and (3) in a manner similar to that of crystalline extractives. When contrasting the optical effects manifested by untreated and by extractive-free fibers, it will be noted that in passing from the untreated to the extracted the color becomes more uniform, the shade of color becomes lighter, and the intensity of luminosity increases.

Lignin as isolated from wood appears non-luminous when observed between Nicol prisms. Its presence in the cell wall of the fibers interferes with the transmission of polarized light and also imparts a yellowish color to the luminous cell wall.

Cellulosic fibers from which the extractives and lignin have been removed appear as a brilliant snow-white material, when oriented properly between Nicol prisms. Except for the intensity and the color of the luminosity their behavior is the same as that of the untreated fibers in the various orientations between prisms.

Fibrils that have been isolated and oriented at the same angles as the cellulose fibers between Nicol prisms manifest the same optical properties as the fibers except that a slight change in the angle of orientation produces a greater change in the degree of luminosity.

Fusiform bodies exhibit the same optical properties as the fibrils except that the angular orientation is more critical for the smaller units. The fusiform bodies, therefore, are evidently the units that give wood its optical properties. These properties are modified by the extraneous materials as well as by the arrangement of the fusiform bodies.

It is quite probable that still smaller visible building units in the fusiform bodies will be discovered in the near future, and that the source of the optical properties described in the preceding paragraphs will then be found in the newly discovered units.

Summary

1. The location in wood substances of two forms of lignin is described. The two forms are shown in photomicrographs.

2. The cell wall of a wood fiber is composed of several layers, which can be loosened by chemical means and then separated mechanically.

3. The layers in the cell wall of a wood fiber, in turn, can be separated into fibrils by chemical means. The fibrils in the outer layer are oriented at approximately right angles to the fiber's axis, whereas those in the remaining layers are oriented from zero degrees to 30 degrees thereto.

4. The fibrils can be separated into regularly shaped fusiform bodies.

5. When either lignified or delignified wood fibers are treated with swelling agents, the fiber walls thicken outwardly and also inwardly. When lignified wood fibers are treated with swelling agents the over-all volume is increased by an external thickening of the cell wall and also by a swelling of the cementing material. On swelling, cross sections of lignified fibers retain their polygonal shape; those of delignified fibers tend to assume a circular shape.

6. The major optical properties of wood fibers in polarized light are inherent properties of the smallest building unit thus far isolated.

7. Cellulose and lignin prepared from wood can be distinguished by their respective optical properties.

THE USE OF MICROORGANISMS IN CERTAIN COMMERCIAL PROCESSES

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GLANCING through some of the modern mycological literature presented in abstract form from all corners of the earth, one is struck by the increasing number of articles on two very interesting subjects. One deals with human pathology and describes the causal agency, symptoms, and control of certain diseases of man caused by fungi. One may read of mycosis or penicilliosis of the hand or foot caused by species of *Penicillium,* or of an aspergilliosis of the ear, caused by *Aspergillus,* a mold-like fungus. Nearly everyone has heard of ringworm of the scalp, which is a skin disease caused by a parasitic fungus attacking the base of the hairs. Our magazine advertisements are now carrying accounts of a new skin disease of the feet caused by *Trichophyton interdigitale* apparently introduced from the Orient. A fungus, *Penicillium bertai,* is described as the cause of a broncho-pulmonary mycosis of man. From New South Wales comes a report of a new skin disease of sheep caused by a fungus not yet determined.

The other subject deals with no particular phase of pathology but is even more interesting in many ways, since it embraces a new and promising field in industry and explains the use of fungi in the manufacture of certain products of commercial value. The use of yeasts in the manufacture of alcoholic beverages and in the process of bread making, a process made understandable by Pasteur's classic researches, is not new, nor are the highly developed processes of cheese manufacture, less familiar to us in their practical utilization of microörganisms. The retting of flax by certain bacteria known as *Bacterium amylobacter* through their highly specialized dissolving action on the middle lamella of the flax fibers is not so well known in our country as it is in Europe, but it represents a very important use of microörganisms in commercial practice. *Cladosporium herbarium* is held by some investigators to be the chief dew-retting organism of flax and hemp.

Taka-diastase, a chemical used extensively in the analysis of starch, is collected from the secretions of a fungus, *Aspergillus oryzae,* and is used in the far East in the preparation of saké and soya sauce.

Ensilage, as every one knows, is dependent upon fermentation organisms to render green fodder into a succulent stored food. The retention of the polysaccharides by this type of fermentation is responsibile for the high nutritive value of silage. Several organisms are concerned in this process of which there are a number of modifications. The spontaneous combustion common to silos and hay stacks has been traced by some investigators to microörganisms, but there are others who believe that enzymic action more nearly accounts for the high temperatures.

There is considerable of a background to the study of the microörganisms used in commercial processes.[1] Yeasts and bacteria have not only been used extensively in the manufacture of alcohol but also for such products as butanol, acetone, and ethanol. Vinegar is also produced through the activities of these organisms. About the middle of the nineteenth century it was discovered that gallic acid could be manufactured by the action of molds on tannin, and in 1890 the Germans produced oxalic and citric acid from sugar solutions by growing molds upon the surfaces of such solutions.

Quite recently [2, 3] gluconic acid, which has a list price of one hundred dollars a pound, has been produced upon a semi-commercial scale by the action of species of *Penicillium* upon corn sugar.

The manufacture of acetic acid through the activity of microörganisms has been in prospect for some time and the recent mycological literature reflects the activity in this branch of applied mycology.

The following brief note taken from *Science* describes the use of microörganisms in a process of converting sawdust to commercial acids:

"Indications of a possible future use for the sawdust that now makes useless and troublesome mountains around sawmills were contained in a paper presented by Professor W. H. Peterson, R. J. Allgeier, and Professor E. B. Fred, of the University of Wisconsin. In a coöperative chemical-bacteriological research program, they have discovered how to make the powdery wood waste into acetic acid, the active principle of vinegar, and lactic acid, which is what makes sour milk sour. Both these acids have industrial uses that render their domestic significance an entirely secondary matter. Three steps were involved in turning wood into acid. The first was turning it into sugar, which was done by the old familiar method of treating it with a strong chemical, such as sulphuric or hydrochloric acid. Then the pulp was further treated with a carbohydrate-converting enzyme, contained in malt sprouts. Finally, the process was completed by the addition of a microorganism that has the power to ferment both hexose and pentose sugars into acid. From 80 to 90 per cent of the sugar present was fermented, the resulting mixture of acids consisting of ten parts of lactic to one of acetic. Wood sugar produced by the Bergius process in Germany fermented equally well and gave the same yield and ratio of products."

Another use for microörganisms appears in the process, now in use, whereby pectin, the important ingredient in jelly, is hydrolyzed by means of certain fungi.[4] The extraction of pectin from apple waste may be thus made easy with the additional possibility of salvaging, in the process, certain by-products such as alcohol.

[1] Herrick, H. T., and May, C. E. Molds and Chemical Manufacture. Ind. Eng. Chem. 21: 618-621. July, 1929.

[2] May, Herrick, Thom and Church. Jour. Biol. Chem. 75: 417, 1927.

[3] May, O. E., Herrick, H. T., Moyer, A. J., and Hellbach, R. Semi-Plant Scale Production of Gluconic Acid by Mold Fermentation. Ind. Eng. Chem. 21: 1198-1203. December, 1929.

[4] Pitman, G. A., and Cruess, W. V. Hydrolysis of Pectin by Various Microörganisms. Ind. Eng. Chem. 21: 1292-1295. December, 1929.

Decayed Wood for Pulp

It was not so very long ago that one would have been laughed at had he suggested the use of rotted wood in the manufacture of paper pulp—yet this is what is being recommended today by the pulp and paper associations and by the Forest Products Laboratory, where many of the tests were conducted.

It is a well-known fact that wood in process of decay loses weight and that in the case of most rots the wood becomes discolored and soft. But until recently it was not known how far the loss in weight, the softening, and the change in color affected the yield of pulp. Fungi produce rots which may be grouped under two main heads, the white rots and the brown rots. In the white rots the material left is principally cellulose, while in the brown rots it is mainly lignin compounds.

The experiments have shown that the wood containing brown rots produces low yields of pulp, while that containing white rots may produce relatively large yields. So far the tests have indicated that rotted wood cannot be successfully used for mechanical pulp, but for sulphite pulp the white rots, typified by the ring rot or white pocket rot of conifers, give promise of yielding a news grade of paper the strength and color of which is little below the normal quality produced from sound wood. The effects of only a few kinds of fungi on yield of pulp have been studied, and these were fungi attacking spruce and balsam fir.

Wood that is badly softened by decay will give very low yields per cord, while wood that is not so badly softened but is firm enough to withstand drum barking, chipping, screening, and other mechanical abrasions will produce yields that would encourage the utilization of infected wood.

This development in the field of wood utilization suggests another thought. If white rot, produced by wood-rotting fungi, is utilizable as sulphite pulp, what is to prevent the use of such wood-rotting fungi on a commercial scale in converting waste wood to pulp or near pulp? Obviously, much work must be done and many obstacles overcome before such a reversal of natural processes may be used economically. Research, however, should give us the answer to this and many other questions of a similar nature.

If we can find ways to divert wood-destroying fungi into useful channels of activity, and, instead of allowing them to reduce our useful wood to waste, harness their enzymic power to a process of pulp production or to the manufacture of some useful chemicals, then truly may it be said that we are pursuing our research to some good purpose.

In 1928 a Swedish scientist, studying the fungi responsible for the blueing of wood, noted that a certain blue stain fungus produced, in artificial cultures, a distinctive odor which characterized a valuable chemical used extensively in our present-day activities. This fungus was recently isolated in our research laboratories from western yellow pine wood collected in Idaho and was found to have similar chemical-making characteristics. The fungus is now under intensive study and the by-product of its growth is being analyzed to determine its exact chemical nature. A research project has been outlined aiming at the commercial development of this discovery. If the chemical is of sufficient value and is produced by the fungus in large enough quantities, there next devolves the task of develop-

ing high-production strains of the organism and the best means of growing them on a commercial scale.

The use of microörganisms, particularly fungi, in industrial processes, presents at once many advantages and disadvantages. In general, such a use has the advantage of an even and smooth-running process, good yields with few impurities, minimum supervision, and a low labor cost. When discovered, the use of a particular fungus to produce a certain substance which has previously required costly and complicated chemical equipment and reactions, or to produce a substance found only in nature, marks a decided step forward in coördinating the factors of chemical science with those of botanical science and in welding the two groups of data into a feasible commercial process. The disadvantages lie in the nature of the organism used and its sensitivity to conditions favoring its growth. Carefully controlled temperature, moisture, air, and food conditions are essential and this entails a carefully worked out process based on research in order to insure successful production.

THE NATURAL CONTROL OF FOREST INSECTS

I—THE WHITE PINE WEEVIL, *Pissodes strobi* Peck

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THAT most direct control methods, such as sprays, repellents, banding, and pruning, though they may be suitable and highly effective for ornamentals, are usually entirely too expensive or otherwise inexpedient for large plantations or extensive forest areas, is, of course, a platitude. For such tracts the problem of the control of an insect pest has usually resolved itself to the working out of the best silvicultural practice and forest management. Often, moreover, when direct methods cannot be used, the desirability of employing biological aids, especially insect parasites, has become apparent, unless the forests are to be resigned to decreases in yield, malformation of timber, and death. When both biological control and forest management are combined, an indirect control, which tends to cure as well as to prevent, is more or less in force.

The successful introduction of foreign parasites for the control of imported destructive forest pests is now recognized as no simple problem, but rather an extremely complex one which requires in each case a thorough preliminary study of both the host pest *and* its existing natural control.

In general, economic entomologists study the biologies of injurious insect pests with the hope of applying control measures at points of weakness in their life histories—often an emphasis on the habits of the insect considered and a wealth of miscellaneous field observations prove to be invaluable—but in the past an analysis of the existing natural control[1] of the given species has not always been given the attention it merits.

Artificially fostered biological control, logically, should not be applied until not only the possibilities of such control have been explored, but also until the preëxisting natural control has been duly measured and an attempt made to forecast the efficiency of the introduced control in combination with the natural control. In some cases it may be advisable to encourage the present control and to select insect parasites which will *supplement* it; in other cases, a complete disregard of the existing natural control may be justified. In all cases, however, it would seem eminently desirable that the status of the several factors constituting the existing natural control be adequately surveyed.

[1] "Natural control," as used herein, may be defined roughly to include *all* biological factors, such as insect parasites and predators, birds, small insectivorous mammals, entomophagous fungi, bacterial diseases, and intraspecific competition, and in addition other factors such as winter-killing, heavy-washing rains, fluctuations in the food supply, and the like. This corresponds essentially, of course, to the term, "environmental resistance" used by Chapman, Graham, and others.

Recently, the tendency to consider the ecological background of a forest insect with more care and to attempt to measure the components of its environmental resistance has been manifested. Because these components are numerous and the variables often exceedingly complex, it may be extremely difficult, if not impossible, to express a thoroughly comprehensive "ecological equation" for a given insect. It is not, however, inordinately difficult to secure close approximations of the effectiveness of some of the principal agents of its natural control. Such research would appear to be not only valuable from the standpoint of pure science but very worth while from the economic viewpoint.

This paper presents some original data on the natural control of the white pine weevil, *Pissodes strobi* Peck, gathered between Oct., 1926, and May, 1929, a more complete account of which has appeared elsewhere.[2] In a later paper it is hoped that the natural control of the birch leaf-mining sawfly, *Phyllotoma nemorata* Fallén, upon which research is now being conducted, may be treated in these pages.

The cycle of natural control factors of the white pine weevil, the familiar prime enemy of white pine and to a lesser extent of some spruces and other pines, may perhaps be best expressed in tabular form (Table 1). With this treatment it will be immediately apparent that considerably more is known of some phases than of others. These data must, of necessity, be subject to some error and hence only approximations; they represent, largely, conditions in one area and in one season. It is believed, however, that they should be reasonably indicative of average general conditions in the portion of the white pine belt where the work was done.

Data on bird work are always of interest to forest entomologists. Methods to measure the effectiveness of the feathered enemies of insect pests include (1) an examination of the contents of the alimentary tracts of birds, and (2) counts of the bill marks of birds on infested plant units. In the case with the white pine weevil, the latter method has seemed the more advisable, since soft-bodied larvæ soon form an amorphous mass (virtually indeterminate as to species and often uncountable as to individuals) in the alimentary tract; moreover, they are so rapidly digested that any data obtained applies over a short period only. On the other hand, if the bill marks are characteristic slashes or tears, such as those in the paper-thin bark of weeviled leaders, a reasonably definite approximation of bird effectiveness may be made. With this method, of course, only direct observation will supply the identity of the birds.

Table 2 epitomizes some data gathered in this way.

Data on the *thoroughness* of larval consumption by birds in the attacked leaders only have been omitted from this account, but are available (as are likewise specific data in detail on the several factors affecting the later stages which are listed in Table 1) in the paper cited in footnote 2. It has been considered advisable, because of their possible general interest, to give here some data on the

[2] Taylor, Raymond L. The biology of the white pine weevil, *Pissodes strobi* Peck, and a study of its insect parasites from an economic viewpoint. Entomologica Americana, Vol. 9, No. 4, and Vol. 10, No. 1. 166 pp., 10 pl., 1929.

TABLE 1

NATURAL CONTROL OF *Pissodes strobi* BY STAGES

Stage	Lethal factors	Their effectiveness	Method	Sample	Source of material	Remarks
Egg.	1. Desiccation due to the mining activities of earlier hatched larvæ. 2. Intrinsic lack of viability.	1. Negligible, except near the end of the oviposition period when more of the eggs are laid in pre-infested leaders. 2. Apparently rare.	General observation.	About 10,000 leaders over 3 years.	Eastern Massachusetts.	The eggs, surrounded by pitch, are never parasitized; molestation by young larvæ of *Lonchæa corticis* Taylor, which hatch in same cavity, very rare.
Young larvæ.	1. Starvation due to lack of food resulting from: a. Intraspecific competition. b. Mining in the wrong direction. 2. Insect parasites. 3. Insect predators. 4. Intraspecific injuries resulting in death. 5. Bacteria or disease. 6. Birds. 7. Nematodes.	1a. The food supply of a leader, even under conditions of average infestation, is almost invariably much less than the total number of larvæ would require for successful development into pupæ. From 80 to 90% die from this single cause. 1b. Relatively few do this; it is difficult to distinguish this class except in early instars. 2. Slightly parasitized by *Rhopalicus pulchripennis* Cwfd. and *Microbracon pini* Mues.; sometimes, considerably by *Lonchæa corticis* Taylor. 3. To some extent by such clerids as *Hydnocera verticalis* Say and *Placopterus thoracicus* Oliv. 4. Negligible: Cases of "cannibalism" apparently due to reflex action of jaws of starving larvæ and not purposefully for food. 5. Negligible: Difficult to ascribe decaying larvæ to any primary pathogenic microörganism. 6. Practically *nil*, when larvæ are young. 7. Extremely doubtful *if* a factor; at least, negligible.	Counts and calculations: a. Av. no. eggs laid: 100-150. b. Av. no. medium-sized larvæ in leader: 26. c. Av. no. mature larvæ: about 125. Points 2 to 7: general observation.	a. Based on counts of Graham, MacAloney, Barnes, and author. b. 116 leaders. c. 3009 leaders. Points 2 to 7: 10,000 leaders over 3 years.	a. New York and Massachusetts. b and c. 2602 leaders from eastern Mass.; 407 in small lots from Me., N. H., Vt., R. I., Ct., N. Y., Pa., O., and Mich. (plus a few others from N. J., Md., and Va.).	In the cases of factors 2 to 7, inclusive, it would seem that the larvæ so destroyed would, in all probability, have starved anyway. Hence, from an economic standpoint, these factors are relatively unimportant.
Mature larvæ and pupæ.	1. Birds. 2. Drowned in pitch. 3. Insect predators. 4. Insect parasites.	1. 17-18 % (see remarks). 2. 2-3%. 3. Negligible: Chiefly grass-eating caterpillars of *Dioryctria* n. sp. 4. Maximum: 25-26%; minimum: 16-17%.	Counts of: a. Infested leaders (exit holes, bird tears, etc.). b. Emerged parasites and predators. c. Determinations of their capacity to parasitize or prey, per individual.	3009 leaders.	See "b" and "c" above.	All per cents refer only to the number of surviving mature larvæ (themselves but 10-20% of those which hatched).

TABLE 1—*Continued*

Stage	Lethal factors	Their effectiveness	Method	Sample	Source of Material	Remarks
Adults.	1. Stuck in emergence. 2. Ground birds. 3. Woodmice, shrews, moles. 4. Winter-killing. 5. Birds attacking copulating pairs on leaders in spring. 6. Nematodes.	1. 2-3% (based on no. of mature larvæ) or, since about half of the mature larvæ become adults, 4-6% of this class itself. 2-5. No definite data available. Collectively, perhaps 50% of the emerged adults are destroyed by the total of these four factors. 6. Nematodes are common under the elytra but it is extremely doubtful if they are a lethal factor; if so, they are negligible because oviposition is not noticeably hindered.	1. Counts. See "a" above.	See above.	See above.	The effectiveness of all the factors listed in this table, when added, give the approximation that the number of eggs represented by mating forms the following spring is but 2.5 to 5%. If all factors remained constant, this would provide for a definite increase of the insect each year.

native insect parasites of the white pine weevil.

From Table 3, it is apparent that, while the native parasites of the white pine weevil were not found to be as effective as might be supposed, they are not without value as a check upon this insect. A detailed study of these parasites resulted in the conclusion that it would *not* be feasible [8] to utilize any of these species in applied biological control.

The desirability of artificial biological control for Pissodes has not been negated by this preliminary survey of the existing natural control. On the contrary, it would seem that there is a real need for augmenting the present natural control factors. One or two hardy and prolific species of parasites that would attack the weevil at the optimum time (presumably before emergence of the adults but after most of the natural control factors given in Table 1 had operated) would be welcome additions to the fauna of the white pine region. Since there are many records

TABLE 2

EFFECTIVENESS OF BIRDS IN THE NATURAL CONTROL OF *Pissodes strobi*

Source of material	Number of leaders	Number of leaders attacked	Per cent of leaders attacked	Number of mature larvæ in all leaders	Number of larvæ consumed	Per cent of larvæ consumed
Sidney, Me.	42	16	38	353	55	16
Oneonta, N. Y.	35	16	46	568	76	13
E. Greenwich, R. I.	15	7	47	152	20	13
McConnellsburg, Pa.	7	2	29	47	6	13
China, Me.	32	16	50	381	79	21
Ansonia, Pa.	9	1	11	74	1	1
Readfield, Me.	24	18	75	341	83	24
Sizerville, Pa.	22	8	36	210	24	11
Concord, N. H.	15	8	53	215	50	23
Durham, N. H.	37	6	16	645	16	2
"Northwest," Ct.	13	7	54	69	20	29
Milroy, Pa.	14	4	29	167	15	9
Bradford, Vt.	32	23	72	431	127	29
Mentor, O.	29	12	41	214	41	19
Mont Alto, Pa.	12	8	67	174	75	43
Fayetteville, Pa.	23	11	48	213	75	35
Roscommon, Mich.	26	6	23	237	30	13
Ann Arbor, Mich.	13	3	23	65	5	8
Blain, Pa.	7	1	14	29	3	10
Total	407	173	42	4,585	801	17
Eastern Massachusetts	2,602	974	37	31,351	5,534	18
Grand total	3,009	1,147	38	35,936	6,335	18

[8] Except, perhaps, in rare instances, where the circumstances would be unusual and might seem to merit it.

of parasites of the European members of the genus Pissodes, and *P. terminalis* in the northwestern United States probably is parasitized, there does exist the possibility of finding effective parasites. Other possibilities of control may suggest themselves when the natural control of this pest is further studied.

TABLE 3

THE COMPUTED EFFECTIVENESS OF THE PARASITES OF *Pissodes strobi*

Locality	Number of mature larvæ	Number of destroyed larvæ ascribed to the parasites					
		Eurytom pissodis Girault	*Lonchæa corticis* Taylor	*Microbracon pini* Muesebeck	All other parasites	Total parasitism	
						No.	Per cent
Sidney, Me.	353	22.0	12.6	5.0	22.3	61.9	17.53
Oneonta, N. Y.	568	34.5	216.6	5.9	46.8	303.8	53.47
E. Greenwich, R. I.	152	1.0	10.9	....	8.2	20.1	13.22
McConnellsburg, Pa.	47	7.3	2.5	....	6.9	16.7	35.53
China, Me.	381	33.4	29.0	3.7	22.4	88.5	23.23
Ansonia, Pa.	74	11.5	14.5	5.1	3.3	34.4	46.49
Readfield, Me.	341	11.5	47.1	2.8	11.4	72.8	21.35
Sizerville, Pa.	210	25.0	29.0	4.3	15.6	73.9	35.10
Concord, N. H.	215	26.1	52.0	0.8	7.5	86.4	40.18
Durham, N. H.	645	9.4	493.5	21.6	8.9	533.4	82.69
"Northwest," Ct.	69	14.6	1.2	2.3	4.7	22.8	33.05
Milroy, Pa.	167	2.1	67.9	....	15.8	85.8	51.38
Bradford, Vt.	431	37.5	50.8	8.7	10.9	107.9	25.03
Mentor, O.	214	47.0	....	....	4.2	51.2	23.92
Mont Alto, Pa.	174	4.2	2.5	2.8	6.4	15.9	9.14
Fayetteville, Pa.	213	24.0	8.5	8.7	11.2	52.4	24.59
Roscommon, Mich.	237	53.3	47.1	1.4	30.4	132.2	55.78
Ann Arbor, Mich.	65	33.5	4.8	....	8.7	47.0	72.30
Blain, Pa.	29	....	3.7	....	1.7	5.4	18.62
Total	4,585	397.9	1,094.2	73.1	247.3	1,812.5	39.54
E. Massachusetts	31,351	1,733.4	830.3	879.2	618.7	4,061.6	12.95
Grand total	35,936	2,131.3	1,924.5	952.3	866.0	5,874.1	16.35

(The apparently considerably greater degree of parasitism in most of the localities other than Mass. is due, primarily, to the select quality of the small lots of leaders, which were chosen carefully in most cases for a high parasite content.)

Fysiske og kemiske Undersøgelser over danske Hedejorder. (Physical and chemical investigations on Danish heath soils.) By Fr. Weis. *Kgl. Danske Vidensk. Selsk. Biol. Meddelelser 7, No. 9, pp. 1-196. 1929. Danish with English summary.*

Betragtninger over Hedejordens Værdi til Opdyrkning. Bidrag til en Omvurdering af vore Heder. (Concerning the cultural value of the heath soil. A contribution to a revaluation of our heaths.) By Fr. Weis. *Dansk Skovforen. Tidsskrift 14:339-368. 1929. Danish.*

Om Hedejordens Egenskaber og Metoder til dens Opdyrkning. (Properties of the heath soil and methods for its reclamation.) By Fr. Weis. *Hedeselskabets Tidsskrift 1929, No. 16-17. Danish.*

The entire western and central part of the Jutland peninsula was once covered with that treeless, or practically treeless, heather formation (characterized first and foremost by the heather or ling, *Calluna vulgaris*) which is so characteristic of many regions along the Atlantic Coast of Europe, on the continent as well as on the British Isles. From the Danish peninsula, the heaths extend in a broad belt down through Sleswig, Holstein, and the rest of northwestern Germany—including the famous Luneburg heath—into Holland and parts of Belgium. Numerous are the investigations devoted to this impressive natural formation, and numerous are the attempts to make these infertile areas productive.

In Denmark, where the heaths originally covered such a considerable part of the country, much effort has been spent on them in the last 200 years by the government and by private enterprise, but until quite recently with rather meager practical results. This is not surprising in view of the conditions presented by typical heath land. The soil is largely a very poor sand (glacial outwash), and is heavily podsolized with an extensive formation of hardpan. Alternating with these sand plains are the so-called " hill-islands " consisting of less washed glacial material and representing correspondingly better natural soil conditions. Many of these hills carried a natural tree growth, mainly oak, while the sand plains seem never to have done so. In fact, the present soil conditions of the heath plains may be due largely to a directly preceding tundra stage, as maintained by P. E. Müller in his last work on the heaths (1924).

The striking soil profile in the heath lands received early attention and was very fully described and analyzed in the seventies and early eighties by Emeis in Germany and particularly by P. E. Müller in Denmark. The latter " gave an almost exhaustive account of the podsolization in Danish forests and

heaths" (Tamm, 1920), showing the phenomenon to be a result of a leaching out of bases from the upper horizon, under the influence of acid humus substances, and their deposition in the membranes surrounding the mineral particles in the hardpan or corresponding horizon. He also made absorption experiments with the different strata of the profile, showing an almost complete lack of absorption in the leached layer, and conversely an increased absorptive power in the hardpan horizon. He stressed the ecological significance of this distribution of the absorbing substances and drew attention, in order to substantiate his conclusions, to the characteristic distribution of roots in a pronounced podsol profile.

Müller also commented on the deep plowing which at this time (1884) had been practiced more or less for about ten years in the reclamation work on the heaths, and suggested that similar measures be eventually applied to improve strongly podsolized forest soils. He expected from such treatment an improvement not only because of the transformation of the raw humus, but also as a result of an admixture of absorbing material from deeper horizons. On the other hand, he very cautiously pointed out that the soil improvement obtained cannot be hoped to be permanent unless "the same soil fauna which during thousands of years has protected the hardwood mull against degeneration" becomes established.

Since that time, cultivation and forest planting in the Danish heaths have made steady progress, particularly through the continuous efforts of the "Heath Society," a private association for promoting the reclamation of heaths, founded in 1866 by E. Dalgas. The area of unplanted and uncultivated heath in Danish Jutland has diminished from 1.4 million acres in 1860 to 0.5 million acres in 1919, and the Norway spruce—a species not growing naturally in Denmark—has become as common a forest tree as the native beech, largely because it has been the favored species in the heath plantations. The results of all these efforts have, in recent years, been much more promising than before, and the possibilities of heath lands are at present estimated considerably higher than in older days.

An impetus to the present work of Weis seems to have been the desire to find a reasonable explanation for these good results on soils which earlier proved so refractory. It was hoped, also, to arrive at better methods of site classification for heath soils. Such was the scope of a work by P. E. Müller and collaborators published in 1910. These authors failed to find any consistent correlation between site quality, as expressed by the growth of Norway spruce plantations, and content of nutrients in the parent material. They found, however, a correlation between site quality and the content of fine material (below 0.1 mm.) of the parent soil, although the nitrogen factor seemed to be far more important. The latter result was further substantiated by Müller & Helms in 1913.

Weis' work includes detailed profile studies in a number of plantations on heath land, on both better and poorer sites, as indicated by the growth of the trees. Besides very detailed profile descriptions, the results of a number of laboratory tests on samples from different horizons are given: mechanical analyses and determinations of pH, hy-

groscopic and chemically combined water, "humus" and inorganic colloids, total nitrogen, ammonia, and nitrates. For three localities, complete Bausch-analyses (in all 15) are also given. The main results and conclusions may be summarized as follows:

In accordance with earlier researches, mineral nutrients such as lime, magnesia, potassium, phosphoric acid, and sulphuric acid ran very low throughout unfertilized heath soil. They did not seem to be accumulated in any particular horizon, contrary to some earlier findings.

The pH was also rather uniform, ordinarily ranging between 4 and 4.5 in the humus layer, increasing with depth. An interesting side light is the slight influence of even a strong application of lime on the pH even in cases where the biological effect was very marked.

The content of fine material (the sum of the three fractions below 0.1 mm.) as determined by mechanical analysis was found to be correlated with site quality, in accordance with the findings of Müller and collaborators, referred to above. The weathered upper strata of the profile, especially the hardpan, are richer in fine material than the parent material.

The hygroscopic water content is correlated with the content of fine material, but much more closely with the content of colloids as expressed by the sum of "humus" (organic carbon divided by 0.58) and inorganic colloids (as determined by Tamm's method). In fact, when comparing different localities, an almost perfect direct proportionality was found between hygroscopic water and the sum of colloids. Comparing the different layers in the profile, however, this proportionality did not hold good, the hygroscopicity being relatively higher in the deeper horizons. The author explains this fact by assuming that the precipitated humus substances of the deeper strata are in a more active colloidal state than much of the surface humus. That none of the fractions obtained in mechanical analysis showed close correlation with hygroscopicity, as does the content of colloids, is explained by the fact that in a podsol profile the colloids are largely present as membranes surrounding and firmly adhering to the mineral particles. The mechanical analysis therefore fails to give a true picture of even the inorganic colloids.

On theoretical grounds the author assigns a special importance to the colloids in the heath soils, as being carriers of the absorptive power of the soil, both for water and nutrients. The distribution of the inorganic colloidal complex in the profile further constitutes a sensitive index of the degree of podsolization, as already shown by Tamm and Lundblad, using the same analytical method. But the author also finds a good agreement between the value of the soil for cultivation, as estimated according to current practical methods, and the content of colloids and their distribution in the profile. He hopes in this way to arrive at a workable method for site classification of heath lands, taking the podsolization as a measure of the difficulties of reclamation and the total content of colloids as a measure of the potential value after cultivation.

Inasmuch as the present work is the most extensive application thus far of Tamm's method for determining the inorganic colloidal complex, the warm recommendation given this method by the author is worthy of note, and a short account of the method itself may not be

out of place. Its principle is to digest the soil with an acid oxalate solution so adjusted (pH about 3.25) that it effectively dissolves the colloidal complex without attacking the mineral particles to any extent. Even with soils rich in clay, the method seems to work far better than first expected, giving errors of only 0.2 per cent or less.

The most original main feature of Weis' present papers is his appreciation of the iron-humus hardpan common in the heaths and particularly in the type of heath which has of old been considered the most hopeless. Weis considers the hardpan as having high potential value because of its large content of colloidal material and also of nitrogen. The nitrogen content of the "humus" increases with depth and averaged in Weis' analyses 2.25 per cent in the hardpan making this layer contain between 0.1 and 0.3 per cent total nitrogen. One half or more of the iron and alumina content of the hardpan was present in the form of gels, and with the high content also of humus the hardpan contains the bulk of the supply of colloids of the entire profile, by no means a negligible amount. After mixing the hardpan with the upper layers of the profile by deep and thorough working of the soil, and after proper liming and fertilizing, a soil will result, the author says, which is no longer among the poor sands, but is comparable to light types of good agricultural soil. These measures are also likely to mobilize a considerable part of the inert nitrogen contained especially in the raw humus and the hardpan, which will be another important factor determining fertility.

The physical and chemical studies of the heath soils, to which these somewhat optimistic conclusions pertain, cannot be said to have revealed anything radically new. Theoretically, P. E. Müller could as well have drawn the same conclusions in 1884. The difference between Müller's discretion and Weis' positivism is rather due to the fact that the practical efforts on the heaths have lately been much more successful than earlier. The big factors in the change have been, according to Weis, the introduction of the Hanover plow after 1870 and the increased use of lime and marl. The merit of Weis' contribution is essentially to have given a reasonable explanation of the practical results.

The reviewer wishes to stress that the foregoing statements do not imply any blame against either P. E. Müller or Fr. Weis. The cautiousness of the former, at a time when practical experience had not shown how far the scientific indications would hold in practice, was not only wise, but a model to follow, when dealing with such an immensely complicated object as soils. When research men in such a branch have ventured to do what many practical men still want them to do, *i. e.,* to deliver practical schemes ready for use fresh from the laboratory, men of practice have been very wise in taking the recommendations with a grain of salt, as for instance when Liebig promulgated his law of the minimum, claimed that fertilization should be adjusted according to the composition of the plant ashes, and maintained nitrogen fertilization to be unnecessary. On the other hand, the real every-day benefit to practice derived from the coördination of otherwise isolated, disconcerting empirical facts by means of a sound explanation, or even a sound hypothesis, should not be underestimated, as is often done.

Any contribution of this kind, such as Weis' present work, is a real service also to practice. In the case of Danish heaths, Weis' results will no doubt be an important factor in the rapid extension of the best practices which neither have been generally applied, thus far, nor universally favored by practical advisers.

Under the conditions at present prevailing in this country, the direct practical application of the experiences in the Danish heaths is no doubt very narrow. Even in Denmark, it seems to be a serious question whether the forest plantations on the heaths represent sound investments of money and effort. It is characteristic that Weis in his work, which was done under the auspices of the Danish Forestry Association, gets more and more interested in the agricultural aspects of the matter, and that his optimism seems to have been stimulated largely by agricultural experience. This seems quite natural, inasmuch as there is not an alarming gap between regular practice in agriculture and the measures needed, according to Weis, to put the heath soil in good shape, while there seems to be a vast distance between this and the measures which even a reasonably intensive silviculture can ordinarily afford. The reviewer would not be surprised if the Danish heaths should furnish a classical example of the futility, as a general rule, of the common statement that the right place for forests and forestry is on all soils which are too poor for agriculture.

Apart from the high initial costs of preparing the soil in such a way as to take full advantage of the treasures hidden in the heather raw humus and the hardpan—deep plowing, eventually working with Siemen's "soil shredder," and heavy lime or marl application—it seems still to be a question how long even such a thorough preparation insures a good condition of the soil after it has been planted to spruce. One of the major factors making a good, productive forest soil is a sufficiently rapid mobilization of available nitrogen, and Weis no more than his predecessors has been able to elucidate the many mysteries concerning this important point. It is true that, according to a quite general experience, working of a raw humus soil materially improves the nitrogen mobilization. However, as long as it is not known whether this effect is due to an improved aeration, to an increased supply of electrolytes, to a partial sterilization effect, or to anything else, it cannot be said in advance how long the good effect is going to last. In the heath plantations, a notorious difficulty has been at least a temporary stagnation of the young spruce with signs of nitrogen starvation, in spite of the huge nitrogen reserves contained in the soil. Soil preparation including deep plowing previous to planting has earlier been found not to prevent this stagnation from setting in after about four years, even when combined with liming and other mineral fertilizing (Müller & Helms, 1913). It is not clear to the reviewer whether this difficulty has now been overcome, and whether experience has shown any kind of preparation of the heath soils to insure more or less permanently a good soil condition with constant sources of available nitrogen.

Although it still seems to an outsider as if the plantation enterprise in the Danish heaths were not too alluring from an economic point of view, this does not necessarily exclude a possible

practical application of the directions given by Weis, even under present-day conditions in this country. In fact, it suggests itself to try them on some of the most refractory, dry, and heavily podsolized sand plains in the Adirondacks, if it is considered essential to have such land reforested.

Apart from any direct application of directions or results, the wealth of data contained in Weis' work is of considerable general interest as exemplifying the properties and behavior, after certain treatments, of a poor, strongly podsolized soil, and helping to understand the site characteristics of such soil. There are examples enough of heavily podsolized soils in the relatively cold and humid northeast corner of the United States, as in the Adirondacks, the Green Mountains, and the White Mountains, to warrant an interest in the work also in this country, where the heather is a rare plant instead of a scourge.

L. G. Romell.

Biological Decomposition of Some Types of Litter from North American Forests. By Elias Melin. *Ecology, Vol. XI, No. 1, pp. 72-101, 1930.*

The practical importance of humus characteristics in silviculture is being increasingly recognized. The humus, through its influence on soil conditions, has an important effect on the rate of growth. This influence is of several kinds: (1) On fertility, both through the constituents which the humus, on decomposition, yields to the soil, and through leaching out of lime and other bases by water acidified as it passes through the humus; (2) on physical characteristics, the soil under a blanket of raw humus being more compact than under a rapidly decomposing mull. These are only some of the more conspicuous effects.

It is known from the work of Hesselman, Melin, and others that the leaves of different species create different humus conditions. Hitherto, only European species have been studied. Melin's is the first work on American species. The results which he presents in *Ecology* cover principally the rate of decomposition and some of the leaf constituents affecting the rate. Complete chemical analyses will be presented in a separate paper. The species investigated include the more important ones of northern New England forests. They were white pine, pitch pine, red spruce, beech, paper birch, gray birch, aspen, sugar maple, red maple, and white ash, among the trees; and *Aralia nudicaulis, Pteris aquilina, Kalmia angustifolia,* and *Vaccinium pennsylvanicum,* among the shrubs and herbs. European larch from a plantation in Pennsylvania was also included. The leaves were collected on Mt. Desert Island, Maine, except for the larch and sugar maple which came from Pennsylvania, together with some of the beech and white pine leaves. In the tests, the leaves from each locality were kept separate, even to the leaves from different parts of Mt. Desert Island.

Decomposition was investigated under controlled uniform laboratory conditions, the rate being indicated by the evolution of CO_2 and by the quantity of reduced organic matter after four months at 24° C. Other things being equal, the more rapid the decomposition, the more

favorable the leaves in humus formation. Tables and curves are presented showing the rate for the different species. The most rapid was white ash. Soft maple and paper birch were fairly rapid. Among the conifers, the white pine from Pennsylvania was the most rapid, while that from Mt. Desert Island was relatively slow. One of the surprises was the slow decomposition of beech, which indicates that the American beech lacks the favorable qualities of the European species as a soil improver.

It was found that for a given species there was on the whole a parallelism between the total nitrogen content and the rate of decomposition. The higher the nitrogen, the greater the quantity of CO_2 developed. Yet this parallelism does not hold as between different species, and the factors influencing the rate of decomposition seem to vary with the species. In some it may be high lignin content, in others low nitrogen, and so on. Melin concludes that probably the internal factors affecting decomposition are characteristics of species.

Further work of the kind which Melin is doing will furnish a basis for intelligent choice of species in mixtures. While we already know that pure coniferous stands create unfavorable soil conditions, it is important to leave, not merely any broadleaf species, but the ones which best combine economic value and soil improving qualities. Investigations like those of Melin should be even more important in the United States than in Europe, because our abundance of natural hardwood reproduction gives us much more opportunity to pick and choose the most desirable species.

B. Moore.

Le Sol et la Forêt. Études pédologiques, appliqées aux sols forestiers. (Soil Studies Applied to Forest Soils.) By E. Hess. *Annales de la Station Fédérale de Recherches Forestières, Vol. XV, Facs. 1, pp. 5-50, Zürich, 1929.*

Neue pedologische Untersuchungen und ihre Anwendbarkeit auf forstliche Probleme. (Recent Soil Studies and Their Applicability to Forest Problems.) By E. Hess. *Schweizer. Zeitschrift für Forstwesen, 38 pp., Bern, 1929.*

Hess presents several rather striking examples from Swiss forests of the influence of silvicultural methods on rate of growth through the influence exerted on the formation of raw humus. Under a selection forest there were 15 to 25 cm. of non-acid humus (pH 6.8—7.1) in intimate contact with the mineral soil, which contained 8.6 per cent of lime. Under a mature even-aged high forest there was a layer of 15 to 20 cm. of acid humus (pH 4.1—4.3) sharply separated from the mineral soil, and below it a leached or podsolized layer without lime. The soil type in both cases was the same, and contained a high percentage of lime. The composition of both stands was approximately the same, the selection forest having 60 per cent spruce and 40 per cent fir, and the even-aged forest 70 per cent spruce and 30 per cent fir.

Hess attributes the unfavorable condition under the even-aged stand to the lack of light and warmth necessary for the normal decomposition of the surface litter, though he does not by any means recommend clear cuttings as a solution. Reproduction is abundant on the non-acid humus in the selection forest, and

is lacking on the acid humus. Experiments in which the acid humus was peeled off gave abundant reproduction, indicating that it is the presence of the raw humus and not the absence of light which prevented the establishment of seedings.

B. Moore.

Trees and Shrubs of Minnesota. By C. O. Rosendahl and F. K. Butters. *Pp. vii + 385. 1928. Minneapolis, University of Minnesota Press. $4.00.*

During recent years, many publications have appeared describing the forest flora of different states. Most of these are nothing more than a rearrangement of some of the already known facts. Occasionally, to be sure, a few new illustrations are added, but on the whole many of these publications do not constitute even a careful and critical digest of what is already known about the flora of the particular state.

"Trees and Shrubs of Minnesota" is of an entirely different stamp. It is the result of over twenty years of continuous work and study, not only of the material in the herbarium of the Department of Botany at the University of Minnesota, but also of the trees and shrubs in their native habitats. In all, 47 families, 107 genera, 324 species, 40 varieties, 14 forms, and 18 hybrids are dealt with. These include not only the indigenous trees and shrubs, but also the introduced forms which are growing in the state.

The descriptions of species are original and readable, and are illustrated with splendid drawings showing distinguishing characteristics. The arrangement of families is according to the Englerian System, although, as stated in the preface, the authors recognize the limitations of this system. The International Rules have been followed in all questions of nomenclature.

Mention should also be made of the keys to the families and genera included in the book. These are largely original and clear, and have been proved by experience to be adequate.

The native vegetation of Minnesota is divided into three great regions occupied originally by the evergreen forest, the deciduous forest, and the prairie. The deciduous forest region in turn is divided into several rather distinct subregions: (1) The forests of the southeastern corner of the state; (2) the region of open woods about the Twin Cities; (3) the heavy forests of Chisago and Isanti Counties; (4) the deciduous forests of northeastern Minnesota; and (5) the bottomland forests. Three subregions of the prairie are recognized: (1) Prairie; (2) bottomland forests; and (3) woody vegetation of the prairie proper.

Many foresters will find a new departure in the authors' treatment of the genus *Juniperus*. The genus *Sabina* is conceived to include those forms ordinarily considered as junipers having usually opposite leaves and naked buds, while the true junipers are conceived to have needle-like leaves in whorls of three and scaly buds.

Anyone wishing reliable information concerning the trees and shrubs of Minnesota will find Rosendahl and Butters' book of great interest.

Henry Schmitz.

The Growth of Eucalyptus on the High Veld and Southeastern Mountain Veld of the Transvaal. By J. J. Kotze and C. S. Hubbard, Research Branch, Forest Department, Pretoria. *Forest Department Bulletin No. 21. Pp. 59, map. Government Printing Office, Pretoria, 1928.*

This is principally a planting bulletin, with abundant data on rates of growth, thinning, enemies, etc. The subject is discussed for three different regions, of which the high veld proper is the most extensive. The planting of Eucalyptus in South Africa on a large scale dates from the opening of the mines about 1888-1890 and the large demand for mine timbers. This, however, has allowed time enough for a couple of complete rotations with species which, at their best, reach heights of 70 to 80 feet in 15 years, producing 200 cubic feet of wood per acre per annum. As in California, the species which have attained the greatest popularity are *E. viminalis, E. maideni,* and *E. globulus,* presumably because they are inherently the most rapid-growing, and not because of similarity of site conditions in the two regions. However, all three of these species have been so severely attacked by the snout-beetle (because of their more frequent occurrence?) that further planting of them is not recommended. Moreover only *E. viminalis* is particularly frost-hardy and suited to general planting.

While these fast-growing species, together with *E. rostrata* and *E. sideroxylon,* suffice well enough for mine-timber production on a rotation of 15 to 20 years, those which yield a valuable hardwood, including the last two species above and *E. eugenioides, E. botryoides,* and *E. robusta* are recommended for sawtimber, on rotations which will probably vary from 25 to 60 years, according to species and site.

C. G. Bates.

Forest Conditions of Queensland. By E. H. F. Swain, Chairman, Provisional Forestry Board. (*Prepared for British Empire Forestry Conference in Australia, 1928.*) *Pp. 70. Government Printer, Brisbane, 1928.*

This is a critical and scientific discussion of the natural forests of Queensland, largely from the ecological standpoint, and must take a high rank among papers on plant geography. The thoroughness of the work, for so early a stage of forestry development, can only be appreciated by reading, and the difficulty of the task by the realization that Queensland, on the eastern end of the Australian continent, has an area of 670,000 square miles, greater than the combined areas of the British Isles, France, Germany, and Italy.

Queensland lies about one-half above the Tropic of Capricorn, and its temperature varies, nearest the equator, only from 70° F. in winter to 85° F. in summer, while the change from north to south is about 30° F. Within this range, however, there are the greatest imaginable variations in precipitation, more than 10 per cent of the area receiving less than 10 inches of rainfall per annum, and about 15 per cent more than 40 inches. Conditions vary, therefore, from tropical jungles in the lowlands, to arid desert. Wind and evaporation are very important factors, many drainage areas showing only about 5 per cent run-off

with precipitation in the neighborhood of 30 inches annually, while the highest run-off noted during two years was 58 per cent with a total rainfall of 79 inches per annum. These variations are the basis for dividing the country into six major phytogeographical regions, although there are types which recur with great frequency according to local conditions.

The flora of Queensland is, of course, utterly exotic to anyone accustomed only to the Northern Hemisphere. Even the genera are for the most part different. Besides 100 species of *Eucalyptus*, Queensland boasts about 300 varied forest trees, or in all nearly five times as many as attain to any importance in the entire temperate Northern Hemisphere. Of this vast number the most intriguing are the ancient representatives of the families Pinaceae and Taxaceae, namely *Araucaria, Agathis, Callitris*, and *Podocarpus*.

Anyone whose scientific interest leans toward the exotic and deeply mysterious will find this bulletin good reading. To the practical student of silviculture it is likely to be only confusing, since the vegetation of Queensland seems to violate all orthodox laws.

C. G. BATES.

British Hardwoods, Their Structure and Identification. By L. Chalk and B. J. Rendle. *Bul. 3, Forest Products Research, Department of Scientific and Industrial Research and Imperial Forestry Institute. London. Price 5 s.*

The aim of this bulletin is to describe, in simple terms, the structure of all hardwoods grown in the British Isles which are of any economic importance apart from fuel. Technical terms have been avoided as far as possible and those which have been used are explained in the brief account of the structure of wood.

Descriptions and excellent photomicrographs are given of various species of alder, ash, hickory, tree of heaven, Queensland maple, Tasmanian beech, yellow poplar, beech, birch, box, cherry, chestnut, elm, black locust, hazel, holly, hornbeam, horsechestnut, laburnum, lime, maple, mulberry, oak, red gum, she-oak, silky oak, Tasmanian oak or ash, pear, sycamore, poplar, walnut, East Indian walnut, Queensland walnut, African walnut, and willow.

HENRY SCHMITZ.

Denudation of the Punjab Hills. By B. O. Coventry, Conservator of Forests, Punjab. *Indian Forest Records Vol. 14, Part 2, 31 p. illus., Calcutta, 1929.*

The forests of the Punjab (northwestern India) have deteriorated greatly in quality and in certain localities have been exterminated as a result of fires and overgrazing. Moreover, erosion has progressed to a point where the future productivity of the land is generally reduced and in places actually destroyed. In many respects the situation is analogous to that found in the western United States, where grazing is an important industry. Vested grazing "rights" are shown to be at the bottom of the trouble in India. When administrative control of public lands was initi-

ated, the authorities were very liberal in granting "rights" in order that some form of management might be effected with the least possible friction. Because of this leniency conditions have grown decidedly worse the last fifty years. Americans can draw a lesson from this, and those who followed the grazing controversy which raged in the United States a few years ago will be particularly interested.

The author handles the descriptive material from an ecological point of view. In the drainage basin of the Indus where the Punjab is situated, topography and climate vary enormously. From sea level on the southern plains, elevations increase to 20,000 feet in the Himalayas. Rainfall ranges from 5 to 30 inches on the plains and may reach 50 to 100 inches in the mountains. Accordingly, the forests are grouped under several climatic zones and conditions are discussed for each. "In the sub-tropical zone the climax formations of olive (*Olea cuspidata*) forests and other mesophytic types are changing to brushwood forests of sanatha." Erosion as a result of heavy overgrazing has removed the top soil so that the valuable species which need this humus soil for regeneration are dying out.

"In the sub-temperate zone the mesophytic and climax formations of oak (*Quercus incana*) are changing to chir pine (*Pinus longifolia*), and the chir pine forests are generally deteriorating in quality." Chir pine forests are burned periodically to rid the soil of pine needle litter to make room for grass. Erosion has followed each burning. Chir pine being thick barked has been able to stand the fires, and requiring bare mineral soil for regeneration has been able to persist. But following each fire more and more erosion occurs and the site quality has gradually been lowered. In places all of the soil is gone and the chir pine remains to grow only in rock crevices.

"In the temperate zone climax formations of oak or other broadleaved species are changing to blue pine (*Pinus excelsa*). In other words, there is a general tendency for the climax and mesophytic types to change to more xerophytic types indicating a general change from moist to drier soil conditions."

Much of the denudation has resulted in recent years from the increase in population and more intensive use of the lands. Old records and examples of forests in protected places (for example, around old tombs) support this contention. Most of the denudation is directly related to overgrazing and to fires set to improve grazing.

Need for forest conservation was recognized as early as 1855. Some years later the government forest department was organized and rules drawn up for the management of public lands. A few small tracts were reserved from all grazing, but on the lands outside the reserved forests practically unrestricted grazing was permitted. Liberal recognition was given to grazing "rights" and overgrazing has continued. It is especially bad on the common village lands.

The remedial measures suggested resemble in some respects those proposed to correct conditions in the United States, but in others they are unique. Organized pasture management is regarded as the only solution. There are more stock than the ranges can carry in their present depleted conditions. It is proposed that certain areas be denuded of trees and handled as pastures pure and

simple. Grass will hold the soil and with the removal of the competing forest cover the incentive to burn would be largely eliminated. Other areas would be handled for the production of grass (hay) crops, to be cut after seed has fallen. Fear is expressed that the rural people will do nothing to correct matters and that the Government will be forced to take action. It is also suggested that one solution for the grazing problem on the common village lands would be allocation to private ownership with the relinquishment of grazing "rights."

F. H. Eyre.

The Rate of Interest in Forestry. By M. D. Chaturvedi. *Indian Forester 15: 10-20, 74-80. 1929.*

This article brings out several factors ordinarily given very little consideration in the discusion of interest rates as applied to forestry undertakings. According to Chaturvedi, one of the most important of these little considered factors is the changing purchasing power of money. The real value of money tends constantly to depreciate as population increases and as civilization advances. In Europe and India this depreciation in the value of money has gone on steadily during the last 50 years. With it has come a great reduction in the real increase in value of savings accounts, carried forward at definite rates of compound interest, as compared with the nominal increase in value of such accounts as represented by the amount of money which the savings bank is to pay to the depositor at the end of any term of years within this period.

In India the depreciation in the purchasing power of the rupee has averaged $2\frac{3}{4}$ per cent per year for the last 50 years. Hence, a savings account upon which 4 per cent compound interest was paid throughout this period actually increased in real purchasing power at the compound rate of only $1\frac{1}{4}$ per cent per annum. The author then goes on to show that timber prices, during the last half of this period have followed quite closely the mean price index of all commodities. Hence timber prices are found to advance at approximately the same rate as that at which the real value of money has gone downward. Hence, the per cent rate earned by a forest investment represents a real rate which is approximately equal to the nominal rate which the forest is calculated to earn. Hence, during the last 50 years a forest investment yielding a compound rate of $1\frac{1}{2}$ per cent annually would have been as profitable as a bank investment yielding a compound rate of 4 per cent annually.

Assuming that this tendency of money to depreciate in purchasing power is to continue in the future as it has in the recent past, the normal depreciation in the value of money becomes a factor of great importance in comparing the advantages of forest investments with investments in bank savings accounts, in loans, etc. This comparison works out in favor of forestry investments and against money loans, unless the latter yield a rate of interest appreciably higher than forestry investments.

In his consideration of the factors which have brought about a rather steady decrease in the purchasing power of money during the last 50 years the author has not included any reference to the

relative supply of the metal making up the money base. In gold standard countries the stock of gold available as a base for money has increased during this period more rapidly than commercial needs have required that it should increase. Hence, from this cause alone, there has been an appreciable decrease in the purchasing power of money.

Will this rate of increase in the stock of gold, available for use as money, continue indefinitely into the future as during the recent past? Probably not. A change in the rate of gold production might either help or hurt the investment rating of a forest investment as compared with loans payable in money, rather than in goods. Whether or not such a change in the stock of gold would hurt or help the forest investment would depend to a considerable degree upon how we solved the general monetary difficulty thus brought about.

Another interesting and pertinent point raised by Chaturvedi is the relation of forest economics to national economics. He indicates that the establishment and maintenance of non-profitable forests, no matter how desirable they may be as protection forests, cannot be justified from a forest economic point of view, but that the establishment and maintenance of forests that in private ownership would be unprofitable may and often can be justified from a national economic point of view. From a national economic point of view, the establishment and maintenance of such forests is justified if the savings to the nation brought about by the presence of these forests is greater than the cost to the nation of such forests.

J. H. Allison.

Zur Vogelschutzfrage, in besondere zur wissenschaftlichen Begründung des wirtschaftlichen Vogelschutzes. (The bird protection question with special reference to a scientfic foundation for the economic protection of birds.) By Wilhelm Freiberger. *Allgemeine Forst und Jagdzeitung 103: 19-30, 49-63, 92-114. 1927.*

Foresters and entomologists interested in the question of insect control by means of birds will welcome this comprehensive account of the results obtained in the Hardt region, Germany, in reducing moth damage by encouraging and protecting bird life in the forests. The feeding and stomach investigations of Dr. Rörig are cited as the basis for determining which bird species to favor. In general, smaller birds, such as wrens and titmice, require greater daily amounts of dry weight nourishment per unit of body weight in both summer and winter than do larger birds. Furthermore, the smaller birds feed exclusively upon insects, while the larger ones are often partly carnivorous.

Birds, when present in forest throughout the year, are the most effective means of preventing insect epidemics and reducing insect damage during non-epidemic years. Other methods of insect control—natural parasites, unfavorable weather conditions, and direct control by man—are either more costly or only operative when the insect outbreak already has reached the epidemic stage and the greatest damage has been done. From the standpoint of moth control, three species of titmice—the blue, marsh, and great titmouse—are especially valuable. These

are most useful because they are present in the forest at all seasons of the year, because they feed largely upon all life forms of moths, because they are easily attracted to a forest region when given protection, and because they can be uniformly distributed throughout a forest by means of suitable shelters. In the Hardt region four pairs of titmice per hectare are sufficient to keep down moths and prevent the occurrence of epidemics.

In those parts of the Hardt forests where birds have been protected and sheltered in special bird houses, no insect epidemics have ever occurred, in spite of the fact that such insect-free stands adjoined forests where damage by the pine shoot moth was so severe that large areas had to be clear cut to salvage the insect-killed trees. Insect control by birds versus insect control by insect parasites and the occurrence and growth cycles of moths in stands where birds are protected, in stands where they are unprotected or absent, and in stands where only migratory birds are visitors, are discussed and illustrated by means of tables.

PAUL W. STICKEL.

Über Grundflachenberechnung und ihre Genauigkeit. (Concerning the calculation cf basal area and its accuracy.) Lars Tirén. *Meddlelanden från Statens Skogsförsöksanstalt, Häfte 25, No. 5, 1929. Pp. 229-304, 18 fig. German text, Swedish summary.*

That tree measurements are subject to instrumental and personal errors is usually taken for granted. In this article, the author discusses common sources of error, and also some that are seldom thought of. He points out that although those of the latter class are usually so small as to be negligible in common practice, it is worth while to know what magnitude they can attain.

Temperature affects the diameter of a green tree in rather astonishing degree, especially if the range of temperature extends above and below the freezing point. Freezing forces water from the cells and this results in a shrinkage amounting to about 0.4 per cent of the diameter. Above the freezing point, the expansion is only about 0.005 per cent for each degree Centigrade, a negligible quantity. If, however, a 25-inch tree is measured when the temperature is below freezing, and again at several degrees above freezing, a discrepancy of 0.1 inch may be expected. Thus, if diameters are recorded to the nearest tenth inch, it is readily seen that an appreciable error may result in large trees.

Rate of transpiration also affects the diameter. Records of diameter growth with the MacDougal dendrograph at the Southwestern Forest Experiment Station have shown that during dry periods trees commonly shrink during the day and expand at night. Tirén states that this factor may cause a variation of 0.15 per cent. According to the reviewer's observations, this figure would probably be exceeded in the Southwest.

Departure of the stem form from a true circle obviously introduces more or less of an error when the diameter measurement is translated into basal area. This type of error is positive, that is, the basal area will always be too large. The average error for a stand, however, is usually less than 1 per cent.

According to the author, it is common practice in Sweden to record diameters in whole millimeters, always rounding off downward. The investigation shows that the average error, which is always negative, may in some cases exceed 1 per cent for a stand. It seems strange that such an obvious source of error should be allowed to persist in a country that is noted for its high scientific standards.

When the trees of a stand are thrown into diameter classes in order to simplify computation of basal area, it is incorrect to assume that the average diameter lies in the middle of the class, since actually it may lie to one side of the middle. Thus, the actual average diameter of the 14-inch trees may be 13.8 or 14.3 instead of exactly 14 inches. When this method is applied to a whole stand, the errors tend to be compensating, but nevertheless the final results are usually inaccurate. The error increases with the breadth of the diameter classes. Specific tests showed that in a 1-centimeter classification it amounted to + 0.03 per cent; in a 3-centimeter classification + 0.3 per cent; and in a 6-centimeter classification to + 1.2 per cent. In sample plot work in this country, it is the common practice when volumes or basal areas are computed by diameter classes to determine the actual average diameter to the nearest tenth of an inch. Theoretically, the basal areas of all the trees in each class should be averaged.

Other errors may be classed as instrumental or purely accidental. If the same stand is calipered several times, placing the calipers on a marked point on each tree, the sums of all the basal areas in the different measurements are likely to show some discrepancies. These may be due to peculiarities in the sectional form of the stem, or to irregularities of the bark. Experience in check measurement of trees on sample plots in the Southwest fully corroborates the author's findings in this respect. Errors as high as 1.5 per cent were attributed to irregularities of this class.

The personal equation is a source of error for which it is difficult to make allowance. The maximum figure is placed at + 1.5 to 2.0 per cent. Presumably this takes for granted that the measurements are made by trained men.

Notwithstanding many imperfections, the author thinks that basal area determinations are the most accurate of the measurements which enter into volume calculations. As long as volumes are determined from volume tables, it would seem inconsistent to demand greater refinement in diameter measurements than is attained in the ordinary careful practice.

G. A. Pearson.

NOTES

Factors Influencing Decay of Hardwood Slash in Northern New England and Their Relation to Lopping

A study of the decay of hardwood slash in northern New England by the Northeastern Forest Experiment Station, in coöperation with the Bureau of Plant Industry, shows that the more important factors governing the rate of decay are: The species of tree furnishing the slash, the rate of growth of the tree, the direction of slope where the slash lies, and the moisture of the soil.

Different species of wood vary greatly in their resistance to decay. The species studied are ranked according to relative durability of the slash as follows, beginning with the least resistant: Aspen, poplar, paper birch, basswood, beech, maple, yellow birch, ash, oak, chestnut.

The rate of growth of the tree controls the relative amount of sapwood and heartwood to a marked degree. Sapwood usually rots more quickly than heartwood, but in some species there is little difference. Aspen, poplar, and basswood show little differentiation between sapwood and heartwood, and there is also little difference in rate of decay. Paper birch, beech, maple, and yellow birch show a decided difference in rate of decay of sapwood and heartwood, while the most pronounced differences are shown by ash, oak, and chestnut.

Direction of slope is a more important factor than has been realized. On warm slope the slash may season quickly, become case-hardened, and resist decay for many years. On cold slopes the slash may become waterlogged before decay begins, and also resist decay for a long time. Both conditions result in retarding decay to an undesirable degree. The moisture in the soil also has a very marked influence on these two undesirable conditions of the slash. The species of slash have been ranked in their readiness to become water-logged, grading from those easily saturated to those most resistant, as follows: Yellow birch, beech, basswood, maple, poplar, oak, chestnut, ash. Soil suitable for corn or potato production has about the optimum amount of moisture for the decay of slash.

It has been concluded that lopping will not pay with aspen, poplar, or paper birch, because they rot quickly, and lopping cannot hasten decay appreciably. Lopping is also liable to bring on waterlogging of these species. Beech, maple, and basswood waterlog easily enough so that in most situations lopping is of questionable value, as it places the slash in the most favorable position to absorb water from the soil. Yellow birch slash seems to be especially prone to waterlog, and it should rarely be lopped. On the other hand, a few species, such as ash, chestnut, and oak, resist waterlogging to such a degree that lopping should hasten decay decidedly.

Perley Spaulding.

How Long Does Hardwood Slash Remain a Fire Menace?

Inflammable material left after logging consists of small branches, large limbs, tops, logs, and stumps. Observations by the Lake States Forest Experiment Station over a wide territory in northeastern Wisconsin and the Upper Peninsula of Michigan, during the last four years, throw some light on how long this débris remains a fire menace and how the rate of decay varies with the kind of wood.

Small slash up to 2 inches in diameter of most northern hardwood species such as yellow birch, hard maple, basswood, elm, and beech is almost completely gone in 4 to 7 years. Small slash of white pine and hemlock which occur among the hardwoods remains a source of fire danger from 12 to 15 years.

Large tops, defective logs, and stumps left by the cutting operation constitute a real source of fire danger in dry weather for a much longer time. Stumps usually decay before the logs do.

Basswood logs and stumps are no longer a serious source of fire danger after 10 to 12 years; after 15 to 18 years nothing remains except a rounded heap of mouldy wood.

Sugar maple and yellow birch in 15 to 17 years are so rotten that little inflammable fuel is left in them. The wood of yellow birch possibly rots a little faster than that of sugar maple, but yellow birch bark outlasts that of the latter. The two species, therefore, may be considered as having the same significance from the standpoint of slash danger.

Elm resists decay more than any of the northern hardwoods. Some stumps and logs of elm were found to be fairly solid as long as 25 to 30 years after logging. Although it is probable that 35 to 40 years are necessary to bring about complete rotting of elm stumps and logs, they apparently cease to be a serious fire menace in 20 to 25 years.

White pine, hemlock and white cedar are more resistant to rot than hardwoods, with the exception of elm, and therefore remain dangerous for a longer time as fuel for forest fires. Stumps and logs of white pine were found in almost perfect preservation 35 to 40 years after first logging. White cedar and hemlock must be reckoned with as dangerous slashings for about 20 to 30 years.

These observations are based on average conditions. In wet or dry situations the rate of decomposition may be delayed beyond this average as much as ten years.

H. F. Scholtz.

Effect of Fire on Douglas Fir Slash

To obtain definite information which can be used in formulating slash disposal policies, the Pacific Northwest Forest Experiment Station has begun a study of the slash problem in the Douglas-fir region. Although there are numerous related but widely different aspects to this study, only one phase is treated in this brief summary, namely, the effect of fire on the volume of slash.

As used here the term "slash" includes all forest material left on the ground after logging, *i. e.,* the cull logs, tops, and branchwood, and also the windfalls, semi-rotten logs, and other débris present in every forest. Standing snags and trees are not included.

Data gathered during the course of the survey indicate that after logging is completed there are per acre from 5 to 140 cords (based on 100 cubic feet to the cord) of large pieces, more than 3 inches in diameter and 3 feet long. The reasonably efficient logging operation leaves about 62 cords of this large material per acre—not all of which, however, is perfectly sound wood—representing on an average about 335 pieces. In addition, there are from about 40 to over 200 cords per acre of small pieces of wood less than 3 inches in diameter and 3 feet long. The average amount of this small material is about 90 cords. The ordinary acre has also 3 or 4 cords of rotten (disintegrating) logs. All told, there are about 155 cords of wood débris of all kinds per acre. Snags and unmerchantable trees not felled with the logging operation may blow down and materially increase these volumes.

The slash fire removes from 9 to 49 per cent of the volume of the large pieces, depending upon the severity of the fire and the age of the slash. Ordinarily, a fire in fresh slash probably consumes no more than 30 per cent of the total volume of these larger pieces. If the slash is over 10 years old, it will be drier than when fresh, much of the bark will have fallen, and the fire will remove about 50 per cent of its volume.

A heavy fire consumes at least 95 per cent of the volume of small material. Even a light fire in fresh slash removes about one half of the branchwood and other small pieces. In slash left unburned for 5 or more years after logging, a light fire, if it passes over the entire area, will consume three fourths of this small material.

The fire reduces only slightly the diameter of the larger pieces of slash, but burns entire sections from them. This occurs chiefly where cull logs and down trees or snags are crossed; the amount of wood which a slash fire will consume depends somewhat upon the number of large pieces which are cross-piled by the logging operation.

Since many of the larger pieces of slash are burned in two, there are more logs after the fire than before (averaging about 90 per cent more large pieces), and naturally there is a greater proportion of short lengths than before the fire. After the fire, the large pieces usually are more or less isolated from each other.

Cedar slash appears to burn more readily than any other species. In an area where there is mixed cedar, Douglas fir, and hemlock slash, about 40 per cent of the cedar volume, about 30 per cent of the Douglas fir volume, and perhaps 10 per cent of the hemlock volume will be consumed by the fire. About 15 per cent of the volume of the rotten (disintegrating) logs will be removed by a heavy slash fire.

This quantitative measure of volume reduction in Douglas fir slash by a broadcast burn is but one phase of the slash disposal problem. As the study progresses other factors will be evaluated in the belief that a knowledge of the actual results of various methods of slash disposal will be of practical use in determining the wisest treatment of logged-off lands.

R. E. McArdle.

Seedling Survival on Burned and Unburned Surfaces

Studies by the Pacific Northwest Forest Experiment Station emphasize the variation in surface temperature, with

the attendant loss of seedlings, on natural soil surfaces and on soil surfaces blackened by slash burning. The seedlings under observation germinated on two plots during the period from May 13 to 17, 1929—one a yellow mineral soil surface and the other a black charcoal surface—on a study area in the Wind River Valley, Washington; both plots were exposed to full sunlight. The first hot weather that developed killing surface temperatures occurred from May 20 to 24, inclusive. The temperatures recorded and losses of seedlings sustained during that period are shown in Table 1.

(nipping off seedlings), and 26 per cent to drouth, leaving 11 per cent alive on the yellow soil surface.

The heat injury consists of cooking the tender stem of the seedling at the soil surface. Many of the seedlings under observation, all of them less than 10 days old, showed evidence of heat injury to the stem at 125° F. but the first complete stem failure and death did not occur until a temperature of 135° F. was reached. Following the first hot spell, no critical weather occurred for a month, and by that time the remaining seedlings on the yellow surface had hardened to a point where no further deaths were traceable directly to heat injury, even though much higher temperatures followed. The highest of the 1929 season occurred on July 30 when with an air temperature of 101° F. the surface temperature on yellow soil rose to 147° F., and that on the charcoal surface to 165° F.

Table 1

TEMPERATURES AND SEEDLING LOSS, MAY 20-24, 1929

		Black surface			Yellow surface		
			Seedling loss			Seedling loss	
Date, 1929	Air temp. °F.	Surface temp. °F.	Daily, per cent	Total, per cent	Surface temp. °F.	Daily, per cent	Total, per cent
May 20	89	143	47	47	125	..	..
May 21	85	144	6	53	135	16	16
May 22	89	144	47	100	137	..	16
May 23	83	134	..	..	122	16	32
May 24	81	133	..	..	121	..	32

On the first hot day (89° F.) the temperature on the charcoal surface rose to 143° F. and took a toll of 47 per cent of the seedlings, while the surface soil temperature on the yellow soil rose to 125° F. with no seedling loss. The loss of 100 per cent on the dark surface compared with a loss of 16 per cent on the yellow soil surface by the end of the third day is a striking difference. During the next two days the loss on the yellow soil mounted to 32 per cent, and an additional 10 per cent followed from the after effects of heat injury sustained during the foregoing period. Later in the season a 5 per cent loss was credited to damping off, 16 per cent to insects

The heavy loss of seedlings on the yellow soil surface from all causes combined is mute evidence of the severity of the struggle in seedling establishment. The sudden killing of all seedlings by heat alone on the charcoal surface presages heavy losses for freshly burned areas, and demonstrates how the color of

the surface alone may spell success or failure for a crop of Douglas fir seedlings. Shade from débris and vegetation will help to offset the superheating of exposed charcoal-blackened surface soil, but lacking shade the greatest survival is certain to be where the surface is not blackened by fire.

L. A. Isaac.

Cold Storage Prolongs Life of Noble Fir Seed

Experimental storage tests of noble fir seed by the Pacific Northwest Forest Experiment Station have demonstrated that this seed if kept in cold storage loses its viability very gradually and will be usable for 3 to 5 years, while seed stored at room temperature loses its viability in a single year.

This discovery makes it possible to maintain a constant supply of noble fir seed, and probably other Abies seed, by collecting a surplus every third or fourth year when the bumper crops occur and storing it for use during the intervening years.

A series of tests started in 1921 with seed that was found to be 58 per cent sound (by cutting tests) gave after cold storage a germination of 34 per cent in 1925 and 13 per cent in 1926. A second series of tests started in 1926 with seed that was 38 per cent sound showed a germination of 21 per cent in 1927, 17.5 per cent in 1928, and 13.5 per cent in 1929. Neither tests showed germination after the first year for comparable lots of seed stored at room temperature. The temperature of the cold storage where the seed was kept was approximately 15° F., but probably need not be so cold.

As a result of this study the Forest Service in District 6 has now made cold storage a standard practice for seed of the balsam firs.

L. A. Isaac.

One-Year Storage of White Pine Seed

Samples of fresh white pine seed were stored by the Lake States Forest Experiment Station on November 20, 1928, under conditions as indicated in Table 1, in individual bottles sealed with paraffin, except for one group which were closed with slit corks to permit breathing. The dryness of the seed was fixed before storage by a slow extraction process over sulphuric acid, except check lots whose moisture content was slightly greater than that corresponding to 40 per cent relative humidity.

Original germination of this lot was very erratic, but 7 " checks " germinated in the winter of 1928-29 without pretreatment showed an average germination 31.4 per cent, while the actual original samples in the experiment (three) averaged 30.7 per cent. Some pretreated samples at this same time went as high as 43 per cent, and samples which were stratified until April before starting germination tests gave an average of 47 per cent in 83 days and 60.5 per cent in 167 days, the latter doubless representing nearly the full potentialities of the seed, as the tests were exposed to a great range of temperature and moisture conditions. It may be said, then, that the seed was originally " good " for about 60 per cent germination, but that this could only be brought out by drastic pretreatments, such as stratification. The

outstanding feature of the germination after one year was its much greater promptness, most of it occurring in the first 40 days.

The samples taken from the bottles at the end of one year were soaked about 16 hours in 0.2 per cent sulphuric acid immediately before sowing. This probably hastened germination slightly, although in previous tests neither the immediate nor final germination has been much affected by this sulphuric acid treatment. The results are given in Table 1 for single samples of 500 seeds under each caption.

With the exception of one sample these results are so consistent that there can be no possible doubt as to their significance. The best moisture condition for storage was that equivalent to an atmosphere at 30 per cent relative humidity. The best temperature for storage was not at or near the freezing point but slightly above it with only gradual changes with the seasons. Low moisture content was about equally beneficial under all temperature conditions.

However, in view of the short time involved, these results are subject to different interpretations. These conditions may not be the best for *several* years of storage; there is little sign of deterioration except with the unsealed samples, and it may be that the apparently best conditions were merely best suited to bring out prompt germination at this state in the evolution of the seed. Only *time* can tell the rest of the story. At least it is shown that white pine seed may increase in usefulness through one year of correct storage.

C. G. BATES.

TABLE 1

GERMINATION OF WHITE PINE SEED AFTER ONE YEAR OF STORAGE UNDER DIFFERENT CONDITIONS

Dryness of seed when sealed (Equivalent of atmospheric humidity), per cent	Storage condition: 32° F., constant.[a] sealed.	30-63° F., cellar, sealed	10-100° F., warehouse, sealed	10-100° F., warehouse,[b] unsealed	Average
	Germination at end of 72 days, per cent				
20	67.0	62.4	60.6	51.4	60.4
30	65.6	68.6	66.6	52.4	63.3
40	52.0	65.6	54.2	46.0	54.5
43[c]	60.6	61.2	44.4	48.8	53.8
Average	61.3	64.4	56.4	49.6	57.9

[a] Went up to about 50° F. for a week in the fall of 1929.
[b] The drier samples gained moisture and the 40 and 43 per cent samples lost appreciable quantities from time of storage until taken out. Changes in the sealed samples were mostly less than 1 per cent of the moisture content.
[c] Natural moisture of the seed after all handling, with no artificial heat used in extraction. Artificially extracted seed usually had about 30 per cent moisture and probably needs no additional drying for storage.

ARTIFICIAL VERSUS NATURAL REPLACEMENT ON BLIGHT-KILLED CHESTNUT LAND

Since 1924 a series of three permanent sample plots has been maintained by the Northeastern Forest Experiment Station, in coöperation with the Forestry Department, Massachusetts Agricultural College, on typical blight-killed chestnut land on the Mount Toby Demonstration Forest, Sunderland, Mass. Two plots are located in a northern white pine plantation which was established when

the dead chestnut was removed in 1919. A third plot is situated in a stand in which the blight-killed chestnut trees have not been removed. On one of the two planted plots the competing hardwood sprouts—including chestnut—have been cut back annually so as to release the pines. All plots have been remeasured annually since their establishment.

The 1929 measurements showed that the basal area of pines on the planted plots is rapidly approaching that of all species on the natural replacement plot. For Plot I (weeded pine plot) the basal area per acre was 15.9 square feet; for Plot II (unweeded pine plot), 11.3 square feet; and for Plot III (natural replacement plot), 16.2 square feet. The figures for the first two plots include only the basal area of conifers; for the last plot all species are included. Moreover, in the case of the planted plots the stands are composed entirely of one valuable species—northern white pine. On the natural replacement plot less than half of the stand is of valuable species. In less than a decade, therefore, artificial replacement with northern white pine stock has been successful.

The pines are making better growth where competing hardwood sprouts have been removed annually than those on the check plot. On the weeded plot the trees in 1929 had an average diameter of 1.8 inches, an average total height of 11.7 feet, and approximately 70 per cent were in the dominant and codominant classes. On the unweeded plot the average diameter was 1.6 inches, the average total height was 11.3 feet, and only 50 per cent were in the dominant and codominant classes. The trees on the weeded plot overtop the hardwood canopy by almost three feet; on the check plot the conifors are overtopped by the sprout growth by three feet.

Thus, while weeding of hardwood growth in pine plantations on cut-over chestnut lands is not absolutely necessary, it aids materially in the best development of the planted stock. Where such weedings are undertaken it is recommended that the first one be of a "broadcast" nature (all sprouts on the area cut back) and that subsequent weedings be confined to releasing individual pines. In this study, the "broadcast" weeding of 1925 required 32 man-hours per acre; clump weedings since that date required 6 to 8 man-hours per acre per year.

PAUL W. STICKEL.

HOW MUCH DOES IT COST TO THIN?

In Europe where the product of thinning even in very young stands has a commercial value, thinnings usually pay for themselves or even bring a profit. In this country, thinning, much at it may be desired from the standpoint of the good of the forest, is still a doubtful operation economically, because of lack of market for the product of thinning.

The Lake States Forest Experiment Station, in connection with some other experiments, attempted to determine the cost of thinning in stands of different sizes and density. Three sets of conditions were encountered.

1. Eight acres were thinned in a dense jack pine stand 20 years old. The trees averaged about 2½ inches in diameter. The number of trees before thinning ran from 2,500 to 3,800 per acre. From 1,200 to 3,200 trees per acre were taken out, or from 50 to 85 per cent of the

original number. The cost of thinning varied with the number of trees removed and amounted to from 10½ to 35 man-hours per acre. At a current wage of 37½ cents per hour, this meant an expenditure of $4 to $13 per acre. The products of thinning could not be sold. It even required additional expenditure for piling and burning the brush.

2. Seven acres were thinned in an aspen stand, also 20 years old. There were, on an average, 2,400 trees to the acre, 3 inches in diameter before thinning. The number of trees removed varied from 2,000 to 2,300, leaving from 100 to 400 trees to the acre. The labor involved ranged from 15 to 23 man-hours, or at the current wage from $5.60 to $8.50 per acre. The trees cut out were sold for cordwood and partially paid for the cost of thinning.

3. Three acres were thinned in a 53-year-old pole stand of mixed jack and Norway pine. The number of trees per acre before thinning was 658, the average diameter 6.7 inches. The number of trees removed in thinning was from 158 to 200. The product obtained entirely paid for the cost of thinning and, if the plots had not been so far removed from a market, the thinning would have probably shown a profit.

These cost figures are too limited to permit drawing any general conclusions. The cost of thinning will vary with the cost and efficiency of woods labor, the size of the operation, and, above all, with the proximity to markets capable of using small stuff. Yet it would seem that thinning may be justifiable in very young stands, from 5 to 10 years old, when the thinning can be done with a long knife (machete) at a cost not to exceed $1.00 or $1.50 per acre. Thinning is also justifiable, of course, where the product pays at least the cost. In aspen, that would mean at the age of about 25 years; in a mixed stand of jack pine and Norway pine, at the age of about 40 or 45 years. Thinning in intermediate stages, under the present economic conditions of north central Minnesota, is apparently not yet justifiable economically, except in rare cases.

J. L. Averell.

Progress in the Research Reserve Program

In the Journal of Forestry for May, 1929, L. G. Romell described the purchase by the National Forest Reservation Commission of the Heart's Content tract of virgin timber in the Allegheny National Forest. He said: "It was expressly stated by the National Forest Reservation Commission, when the purchase was decided upon, that the Heart's Content tract was to constitute a 'laboratory' for research to promote forestry." Just how the tract was to be turned into a laboratory he did not state, although he undoubtedly had in mind the recently promulgated Regulation L-20 of the National Forest Manual relating to "Research Reserves" and "Primitive Areas." This regulation, which has not received previous mention in the Journal, prescribes that "the Forester shall determine, define, and permanently record a series of areas of National Forest land to be known as Research Reserves, sufficient in number and extent adequately to illustrate or typify virgin conditions of forest growth in each forest region, to be retained, so far as practicable, in a virgin or unmodi-

fied condition for purposes of science, research, and education."

W. W. Ashe long since expressed the need for such action, and Dr. Romell, with a background of extensive European experience, enthusiastically seconded it. No one who has attempted to decipher the extremely complex pattern of cause and effect which is represented by any forest and its environment, and who has been compelled to work almost altogether on forest land where the warp of human interference has hopelessly obscured the woof of natural factors, can fail to be an enthusiastic supporter of the idea behind research reserves. In silviculture, as in every other branch of applied science, the problem is to "find out which way God Almighty is going, and then get things out of His way." It is a laborious if not almost impossible undertaking to discover the subtle ways of the Almighty in a forest which has long felt the heavy hand of man.

Dr. Romell's title, "Heart's Content, a Promising Precedent," seems to be fully justified by the language of Secretary Ray Lyman Wilbur in his recent report of the National Forest Reservation Commission. This report includes among the objectives of the acquisition program "Promotion of reforestation and timber production on forest lands—by creating means for development of the principles and practices of silvicultural management necessary for successful timber growing in the various forest regions and forest types and on the various forest soils of the country." The report lists among "outstanding features of the work of the National Forest Reservation Commission for the year . . . . recognition of the desirability of the preservation of unmodified or virgin forest areas as nature laboratories for the promotion of silviculture." In describing the Heart's Content purchase the Commission uses the following language: "Notwithstanding the high commercial value of the heavy stand of white-pine timber, it is deemed eminently desirable that the Government should acquire this property, not as a museum site or as a recreational tract but as a laboratory for the promotion of silviculture within which to study both the physical and biological aspects of the changes which take place in such forests, the concomitant changes in the white pine-hemlock forest type, and the manner in which knowledge of these changes may be of value in guiding the development and management of the several hundred thousand acres of cut-over white-pine lands evidently to be acquired as the larger part of the Allegheny National Forest."

These extremely significant statements lend hope to those who have sighed over the lack of virgin areas suitable for Research Reserves within the present boundaries of the eastern National Forests, and have wished that the few pitiful remnants of original growth still in private hands but within the exterior boundaries of the purchase units might yet be acquired for scientific study.

R. D. Forbes.

Relation of Utilization to the Profitable Growing of Trees[1]

It is understood that over 60 per cent of West Virginia's land is in forests, and it is obviously of great significance to the

[1] From an address presented at the West Virginia Commercial Forestry Conference, Charleston, W. Va., Dec. 5, 1929.

state to determine wisely what measures should be taken to perpetuate the future utility of this vast area.

The creation of a sound forest policy requires first some reasonable determination of the final objective sought. It is not enough to say that because vast areas are not now needed for other purposes they should be put to tree growing; the problem is really one of determining how much of these lands are permanently needed for forests for one purpose or another.

While forests serve a great variety of purposes, our future needs for forests fall naturally into two classes—first, the forests, or forest cover, required for their effect on streamflow and climate, prevention of soil erosion, sport and recreation; and second, commodity forests grown primarily for industrial use.

With forests of the first class, we want them to *have,* rather than to cut down. While it is obviously impossible to determine their exact cash value, it is not impossible reasonably to determine their general extent, character, and location, and to take the necessary steps to insure their permanent provision. They are non-competitive with other regions and species; forests in Maine and California, in Minnesota and Florida, will not solve the needs of West Virginia for the protection of its climate, the prevention of soil erosion, and the maintenance of its recreational and social values.

With forests of the second class, which are required for commodity utilization, the situation is entirely different. They are wanted not to have them but for conversion into useful commodities. They are highly competitive, not only with varied species, but with varied regions and with other materials. In the last analysis they must prove revenue-producing rather than revenue-consuming Cash values and profits have become the determining factor in the success or failure of this phase of the forest enterprise.

It is no longer safe to assume that because per capita consumption of forest products has been high in the past it must so continue in the future. As a matter of fact, the per capita consumption of lumber products has dropped from 458 board feet in 1899 to about 284 feet at present, and at the same rate of decrease will drop to approximately 179 feet in 1950.

Furthermore, the days of relatively cheap stumpage are either past or rapidly passing. Whether we like it or not, we face an increasing cost for our merchantable stumpage of the future. If we could merely add this increasing production cost to the sale price of the finished products, the utilization problem would be simplicity itself. Unfortunately, however, we are justified in assuming no such easy solution. While our production costs determine the price at which we can afford to sell, the price of competitive materials will determine the price we can get. Already this is a fact and not a fancy. Increasingly are uses long held by wood being contested by old materials that have been refined by science and by new materials of scientific origin, promoted in industry with the aid of extensive technical knowledge of their properties. Metal lath and window sash, synthetic boards, all-metal automobile bodies, steel desks and spokeless wheels, concrete road bridges, asbestos and tile roofing, metal poles and posts, and synthetic wood alcohol are but a few of the tendencies that are rife.

The problem is complicated even further because of ready and speedy transportation, which has precipitated a veritable war between competitive species of wood in almost all regions of the country. The future profit and loss sheet with West Virginia's commodity forests is inherently bound up with costs of growing, conversion, and transportation in relation to other species, other regions, and the location of future markets of consumption.

Out of this complexity of problems to insure profits in tree growing for commodity utilization, the outstanding requirement is the full development of present and potential values inherent in the forest crop. Its accomplishment will require an enlargement of yearly mercantable yields, an improvement in the quality of the raw product, and a closer and better utilization, including the development of new uses for and from wood. Increasingly must owners and users of timber recognize that theirs is a highly complex organic material, consisting primarily of cellulose, lignin, extractives, and water, the chemical and physical structure of which varies not only between species but within logs of a given species; that it is this resultant combination that determines the 30 or more properties of the wood which control its suitability, or lack of it, for any given use; and that future profits depend on a complete knowledge of the composition, structure, and properties of the raw material, and how most economically to harvest it, select it, prepare it, modify it, adapt it to best fit the technical requirements of utility, and how to convert it into other usable by-products.

The success of commercial forestry will depend very much upon the success with which profitable users are found for present waste material, and with which wood products are marketed in competition with other products. This competition is chiefly with technically developed products, and the only way to meet such competition is to put forest management and conversion on a comparable technical basis. Efforts toward this end by the Department of Agriculture through its Forest Experiment Stations and the Forest Products Laboratory, by the Department of Commerce through its National Committee on Wood Utilization, by forest schools, by the National Lumber Manufacturers' Association, by the American Pulp and Paper Association, and by other wood-using trade organizations, should be supplemented by an increasing attention of state forest organizations.

C. P. Winslow.

Mine Timber Preservation [1]

The Carbon Fuel Company learned by experience that the decay of its min-ties and timber was so rapid that replacements required an inordinate outlay of money. Therefore when it decided to re-open and recondition a mine closed for four years, and found that every tie and many of the posts had to be replaced, it determined to investigate the possibilities of preservative treatment for the wood required in the 15,000 feet of track that had to be re-tied.

It was decided to use treated wood and to install an open cell process plant

[1] Briefed by Emanuel Fritz from an address presented at the West Virginia Commercial Forestry Conference, Charleston, W. Va., Dec. 5, 1929.

using Wolman salts, or triolith. This preservative was decided upon because creosote-dipped material had previously been found objectionable as to handling, and because the zinc salts were considered too corrosive to metal. The plant consists of a 54 inch by 21 foot retort, an air compressor, air receiver, small boiler, and three tanks, one of the latter a mixing tank of 1500 gallons capacity, all housed in a 24-foot by 30-foot steel building. The salt is bought in barrels of 225 pounds each and is dissolved in water in the mixing tank. In the bottom of the mixing tank are perforated pipes through which issue jets of hot water or steam at high pressure to aid in dissolving the salt.

The wood to be treated is run into the retort on small cars. When the wood is green it is subjected first to a steaming process for seasoning. Low pressure steam is admitted to the retort and heat is supplied from the steam coils under the track until the temperature is raised to 175° to 200° F. Following the steaming a 26-inch vacuum is drawn. This process is repeated two or three times depending upon the condition of the wood. Between the time of seasoning and drawing the vacuum the liquid collecting within the retort is drained off, the last vacuum is used to pull the Wolman salt solution into the retort, and having filled it, into the measuring tank. The temperature is raised to 150° F. and a pressure of 175 pounds per square inch is applied and held until the required amount of the solution, as indicated by the gage glasses on the measuring tank, has been forced into the wood. When absorption is completed the pressure is continued to drive the surplus liquid out of the retort into the storage tank where it is held at a temperature of from 100° to 120° F. by steam coils. The salt retention aimed for is one-fifth pound of salt per cubic foot of wood.

If seasoned timber is available the seasoning process is unnecessary, and only a vacuum is drawn as a preliminary to injection of the salts. The use of dry material increases three to four fold the ten-hour treating capacity. Green wood requires a ten-hour shift for treating one retort charge.

To aid drying after treatment a short vacuum is sometimes drawn before the doors are opened. On drying, the water evaporates, leaving the salts, which become insoluble upon "setting," therefore treated wood should not be used at once in wet places. In three months the plant treated 300,000 board feet of wood, about 25 per cent of which was green. In one month when dry wood was used the amount treated was 128,400 board feet.

Not including plant depreciation and interest, the process has cost one cent per board foot for all wood treated. The salt itself cost 0.55 cents per board foot, and the labor for unloading from railroad cars, treating, and stacking cost 0.45 cents per board foot, or a total of 20 cents per tie of 20 board foot size. Based on a ten-year life (more is expected), the cost per tie per year is reduced more than one-half, arrived at as follows:

The cost of 14,000 untreated ties used in three months averaged 50 cents each. The cost of handling and placing in the track, including taking out old ties, placing the new ones, and surfacing the

road is estimated at 50 cents per tie, making a total of $1.00 per tie. In the case of untreated timber, about 2½ replacements would be necessary in ten years, making the cost for the year $2.50 per tie, or 25 cents per tie per year. Treated ties cost 20 cents additional for the preservative treatment, making the total cost in the track $1.20 each. Since their life is expected to be at least 10 years the annual cost is 12 cents per tie, or less than one-half that when untreated wood is used. Furthermore it is no longer necessary to specify oak ties, and woods costing 20 per cent less can be used with equally good results.

NEWTON THOMAS.

SHEPARD GOES WITH PINCHOT

Ward Shepard resigned as Assistant Chief of the Branch of Public Relations of the United States Forest Service on March 31 to become associated with Gifford Pinchot in forest conservation work. Shepard is also Secretary of the Charles Lathrop Pack Forest Education Board.

SOCIETY AFFAIRS

Fritz to Edit Journal of Forestry

It is with regret that announcement is made of the early retirement of Samuel T. Dana as Editor-in-Chief of the Journal of Forestry. He has felt for some time that his other responsibilities, which are indeed heavy, should have first call on his time, and has reluctantly asked the Council to relieve him of the editorial assignment. His work as Editor-in-Chief is known so well and favorably by members of the Society that comment by the Council is hardly necessary. Dana has applied himself unremittingly to Journal of Forestry work and deserves great credit and the thanks of the Society for the high standards attained in the editorial and make-up aspects of the Journal.

The Council has asked Professor Emanuel Fritz, of the Division of Forestry at the University of California, to fill the place to be vacated by Dana after the publication of the May issue. Fritz has had a long acquaintance with the Journal of Forestry and has been a member of the editorial staff for many years.

Professor Fritz was born in Baltimore, Maryland, on October 29, 1886. He was graduated from the Baltimore Polytechnic Institute in 1905, and from Cornell University in 1908 with an M. E. degree. From 1908 to 1912 he was an instructor in the Engineering Department of the Baltimore Polytechnic Institute. He entered the Yale Forest School in 1912 and graduated in 1914 with the degree of M. F. After a half year with the State Forester of New Hampshire, Fritz entered the Forest Service as forest assistant. In 1915 he was assigned as forest assistant to the Cœur d'Alene National Forest in Idaho, and in 1916 saw service at the Fort Valley Forest Experiment Station, on the Coconino National Forest, in Arizona. He entered military service in August, 1917, and was mustered out in 1919 as a captain in the Air Service. In July, 1919, he was appointed a member of the staff of the Division of Forestry at the University of California to handle forest products and wood utilization, the position he now holds.

His contributions to the literature of his chosen field of work have been many and he has also kept well informed of the trend of the forestry movement in the United States. He has been a member of the Editorial Board of the Journal since March, 1922. The Society is fortunate to secure as Dana's successor a man of Fritz's experience in forestry and intimate acquaintanceship with the handling of Journal of Forestry activities.

Paul G. Redington,
President.

Executive Secretary Reports Progress

The writer reported for duty on April 3. Since that time he has been engaged

in studying the functions of a paid secretary for a professional organization. The office file and articles in the JOURNAL have yielded quite a few suggestions. The men here in Washington who for years have devoted a great deal of spare time to the conduct of Society affairs have set forth the possibilities of the office. The experience of similar organizations in other professional fields has been a fruitful source of inquiry. The preliminary study seemed to warrant trips to the Southern Forestry Congress at Memphis, to the American Forestry Association at Minneapolis, and to a conference of members of the Branch of Research, U. S. Forest Service, at Madison. Many foresters were interviewed at these meetings and elsewhere along the way.

The suggestions offered were many and varied. They did not always agree either as to the inclusion of certain projects or the significance of projects which were generally favored. There was, however, an unfailing interest in the new approach of the Society and there was always an earnest endeavor to make the new position one of value to the profession.

It may be of interest to recall at this point the decision of the Council of the Society of American Foresters as set forth June 10, 1925. The Council in deciding on a policy, program, and organization at that time reached the following decision with regard to the position of Executive Secretary:

"The executive secretary will be employed by and act under the instructions of the Executive Council. He will handle most of the current work now falling on the secretary, the treasurer, and the member of the Executive Council in charge of admissions, and will assist in the business management of the JOURNAL OF FORESTRY. He will stimulate and coördinate committee and section activities, and will maintain contacts with affiliated and other organizations working along allied lines. He will keep in touch with forestry activities throughout the country, will inform the Executive Council as to developments on which it should take action, will represent the Society at hearings and meetings, and will perform such other duties as the Council may direct in furtherance of the Society program. He will also render service to individual members by serving as a clearing house for information, particularly with reference to opportunities for employment."

The suggestions received thus far generally agree with the above outline of duties. The Executive Secretary is anxious to obtain the advice and counsel of the many members of the Society who have given thought to the possibilities of service which the office of a paid secretary affords. It will, of course, be impossible to have a personal conference with each individual member. It is hoped therefore that those who have something in mind that will help to make the position of Executive Secretary more serviceable will send it by letter at once. From the digest of these suggestions it is hoped to determine the fields of endeavor that will be most helpful to the profession of forestry.

NATIONAL TIMBER CONSERVATION BOARD

A delegation of leaders in the forest industries and others appeared before President Hoover on April 30 and urged the appointment of a commission to study the problems incident to overproduction in the forest industries. President Redington attended as the representative of

the Society of American Foresters. The idea of some such commission to study sundry forest problems has been under consideration for a long time. The Society of American Foresters will shortly vote its approval or disapproval of a temporary commission to consider the forest problems of the nation. Meanwhile, this approach to a solution for the lumber industry's problem in particular has been accepted by the National Lumber Manufacturers Association and its proposal has been endorsed by the Board of Directors of the American Forestry Association.

The need for a National Timber Conservation Board is urged by the forest industries on the ground that "chronic overproduction in the forest industries is today the greatest threat to desirable balanced use of our forest resources. It is contributing to destructive lumbering, unnecessary waste of wood, and the premature cutting of timber needed in the future. It is having a deadening effect upon forest land values and the practice of industrial forestry. It is making for unemployment . . . ." It is felt that public recognition and study of this situation will lead to a solution that will be helpful to the industry and beneficial to the public. While it is not intended that the Board will attempt a study of the whole forest problem, it is believed that the solution of the problem of overproduction would remove one of the major obstacles in the way of the practice of forestry.

The functions of the committee will be three:

1. Fact finding.
2. Report and publication of finding.
3. Recommendation of national policy.

The Board as proposed would include outstanding men drawn from the general public, the conservation movement, the forest industries, and representatives of the government. It would, in all probability, make use of the facilities of the Department of Agriculture, U. S. Forest Service, Department of Commerce, and Department of the Interior, the organized facilities of the forest industries, the forest schools, colleges, research foundations, farm organizations, and others. The cost, it is understood, will be borne by the forest industries.

It is understood that the President was inclined to favor the appointment of this Board and that foresters will be amply represented on it.

COMMITTEE APPOINTMENTS

President Redington has recently made the following important committee appointments:

R. S. Hosmer, as Chairman of the Committee on Foreign Relations, to fill the vacancy caused by the death of Dean Franklin Moon.

E. A. Ziegler, as Chairman of the Committee on History, to replace Professor Hosmer who made the change as indicated above.

R. C. Staebner as representative of the Society on the Division of Biology and Agriculture of the National Research Council.

ANNUAL MEETING

The annual meeting of the Society of American Foresters will be held in Washington, D. C., December 29-30. The

following Committee on Meetings has been appointed and is already at its task:

G. H. Collingwood, Chairman
F. W. Besley
A. E. Fivaz
E. N. Munns
D. T. Mason
W. R. Hine, *ex officio.*

The early decision with regard to the time and place of the meeting will, no doubt, add materially to the chances for its success.

FOREST POLICY

The Washington members of the Committee on Forest Policy have been holding frequent meetings endeavoring to get the policy statement in shape. Ward Shepard has accepted the task of digesting the opinions from the sections and reworking the policy statement so that it will more nearly meet the opinion throughout the Society. Mr. Shepard's digest is being carefully considered by an executive committee, after which it will go to the general Committee and finally to the individual members for letter ballot.

NEW OFFICES FOR THE SOCIETY

Foresters who came to Washington now find the business offices of the Society in a pleasant suite of rooms on the seventh floor of the Lenox Building, 1523 L Street, Northwest. Three rooms, one for the Executive Secretary, one for the Business Manager, and a larger one for the clerical staff provide a most satisfactory arrangement for conducting the Society's business. It is hoped that many members will find time to drop in at the new offices to discuss Society affairs.

MEMBERSHIP

The membership of the Society is now 1664, as follows:

Fellows	9
Seniors	683
Juniors	907
Associates	49
Corresponding	6
Honorary	10
	1,664

As the result of an effort to bring into the Society those foresters who are entitled to membership, some 300 new members were added last year and 125 were raised from the Junior to the Senior grade.

A request has been sent to the several forest schools for a list of graduates. A request has also been sent to the several federal and state agencies employing foresters for a list of employees. These lists will be checked against the membership file and a prospect list for each section will be compiled. The lists will then be sent to the section interested as an aid in the canvass of foresters eligible for membership.

W. R. Hine,
Executive Secretary.

Nelson Ferris Macduff
1883-1930

Whereas, in the tragic and untimely death on April 4, 1930, of Nelson F. Macduff, a fellow member of the Society of American Foresters, we have suffered an irreparable loss of a fine forester and a true friend; and

Whereas, we shall sorely miss his splendid comradeship, his keen mentality, and his great interest in forestry; therefore,

Be It Resolved, That the members of the North Pacific Section of the Society of American Foresters do hereby go on record as expressing our great sorrow at this loss and our deepest sympathy to his family at the tragic and untimely passing of a splendid forester, a high-minded gentleman, and a faithful friend.

Approved at a meeting of the North Pacific Section, April 18, 1930.

FRED W. CLEATOR,
Secretary.

Nelson F. Macduff, Forest Supervisor and Senior Member of the Society of American Foresters since 1911, came to a tragic and untimely end late in the afternoon of April 4, 1930, near McKenzie Bridge, within the Cascade National Forest of which he had been forest supervisor since 1919.

Going along a beautiful forest trail over which he had walked many times and which he had well loved, a bullet from a gun in an unknown hand struck him down. He fell in a grove of young Douglas firs, and his rangers found him there early the next morning, stretched out quietly and peacefully in his last, long sleep in a forest he loved so well.

Born on July 2, 1883, in Ohio, one of a family of five sons and a daughter of an Episcopalian minister, he had been reared in Michigan. Long before he had left high school in Flint, Michigan, he had chosen forestry as his life's work. Graduating in forestry at the University of Michigan in 1907, with high honors and election to Sigma Xi, he passed the forest assistant's examination and came west as a forest assistant to the Siskiyou Forest, Oregon.

Promoted to assistant supervisor of the Siuslaw Forest in 1910, and after special work out of the district office in Portland on various forests for several years, he became forest supervisor of the Cascade Forest in 1919.

In his eleven years' administration and protection of this important timber forest he labored earnestly, faithfully, and efficiently. He was responsible for its fire detection and communication systems being developed, many roads and trails being built, and a large timber sale made to utilize a big body of overmature Douglas fir. He took a great pride in his forest, and true to his Scottish forebears was relentless in his efforts to provide protection for it, thereby incurring the enmity of the malicious and lawless elements.

During his eleven years' residence in Eugene he made many warm friends, not only among the faculty of the University of Oregon, but among the leading business men of the town. At the time of his death he was an officer of the Round Table of the Eugene Chamber of Commerce, a member of the Executive Committee of the Boy Scouts, and president of the Kiwanis Club. He was held in no less high esteem by his brother forest officers throughout the North Pacific District.

Macduff leaves a wife, Mrs. Alice B. Macduff, a graduate of the University of Michigan, and two children, Betty Ann, a freshman in the University of Oregon, and John, a senior in high school.

A forester of broad training and wide experience, with the highest ideals of his

profession, keenly interested in forestry, holding to high standards of personal conduct for himself and his men, he made many friends both inside and outside the Forest Service.

Having a sound philosophy of life, possessed of a keen sense of humor, he valued most highly his family and his many friends, of whom he was always most considerate. His loss is a severe one to the U. S. Forest Service and to the profession, and a tragic one to his friends and brother officers.

JNO. D. GUTHRIE.

ANNUAL MEETING OF SOUTHEASTERN SECTION

The annual meeting of the Southeastern Section was held at Jacksonville, Florida, on February 26, 1930, in conjunction with the International Naval Stores Conference.

The meeting was called to order at 10.15 A. M. by Chairman I. F. Eldredge, who told of a movement to urge a more adequate salary for the head of the Forest School at the University of Georgia. Captain Eldredge stated that he had been carrying on an extensive correspondence with the larger timber owners and business men generally in the state and had received evidence of a very general interest in the movement to aid the Forest School in every way possible. He stated that there seemed to be a general realization on the part of such men that there would be an increasing demand for foresters in the southeastern region and a feeling that the old established school at the University of Georgia should be encouraged in every way to fill this demand.

E. L. Demmon delivered a very interesting and instructive paper on the relation of research to the naval stores industry. During the lively discussion that followed Dr. Ziegler described the economic survey he had just completed of the timber business in Appling County, with particular reference to the naval stores industry. Capt. Louis Andrea, of the French Forest Service, a delegate from the French Government to the International Naval Stores Conference, was guest of the Section and made an informal but very interesting talk on the subject of French forest methods in the naval stores region in France.

E. N. Munns, also a guest of the Section, at the request of the chairman discussed the minority report on the national forest policy question which is now before the Society. After some discussion, it was decided to determine the position of the Section by letter ballot at a later date.

The following officers were elected:

Chairman—Harry Lee Baker, State Forester, Tallahassee, Florida.

Vice Chairman—B. F. Lufburrow, State Forester, Atlanta, Georgia.

Secretary-Treasurer—H. A. Smith, Florida Forest Service, Tallahassee, Fla.

W. M. OETTMEIER,
Secretary-Treasurer.

ANNUAL MEETING OF GULF STATES SECTION

The annual meeting of the Gulf States Section was called to order by Chairman G. D. Marckworth in the Agricultural Auditorium of Louisiana State University, Baton Rouge, at 2.00 P. M., March 14, 1930.

R. L. Thompson, Department of Rural Economics, Louisiana State University, presented the first paper on "Some Aspects of the Cut-Over Land Problem." He stated that efforts are being made by some large lumber companies to settle the cut-over lands of the South—most of it marginal or sub-marginal in character. Prices charged in Louisiana are $7.50 to $20.00 per acre, with a down payment of either 10 per cent or $100. Cotton, the principal cash crop of the South, is already over-produced. Grain and feed crop consumption is falling off. Only vegetables and sugar, among the major plant foodstuffs, show an increase. Meat consumption has changed but little. Population in the United States will stabilize at about 186,000,000. No new agricultural lands will be needed for at least 10 years. Timber requirements will be 32 billion cubic feet, needing 500,000,000 acres for its production. His conclusions are that there is sufficient land, both farm and forest, to meet our national requirements for all time. No new farm land will be needed for at least the next 10 or 15 years. Future timber demands will exceed the supply and higher prices warrant the planting of denuded land. An economic classification of cut-over land is needed to prevent improper usage. State and national governments should replant the poorest forest land.

During the discussion the point was made that money is not available for lumber companies to reforest, the government must do it. Let the government sweep its own doorstep before taking in more territory—let it plant up the barren areas already under its control. Ward Shepard's plan has considerable merit. Some sort of a subsidy would reforest these stump lands much quicker than the government could educate the voters into voting bonds or taxes for this purpose. Fire protection alone will not be sufficient—at the best the lands would only be half stocked. For the government to acquire land through tax delinquency is not the correct method and will be very costly in the end.

Many foresters are inclined to paternalism—want the government to run all the timber land, to handle all the grazing land (public domain), and no doubt will soon be demanding federal control of the farming land. There is no use in running a temperature over unnecessary or excess land under cultivation. As long as this is a free, democratic country and there is virgin land available holding out a 50-50 chance for success farmers are going to break out new land and abandon old, so why blame owners of raw land—stump land or prairie—if they can dispose of some of it for farming purposes.

C. H. Guise thought Thompson's objective view very valuable. Favors governmental handling of problem. Most companies are not interested, financially able, or anxious to enter a program of reforestation. States are too unstable politically. The national government must step into the picture. Fire prevention must come first.

E. A. Ziegler, in a paper on the "Financial Aspects of Shortleaf Pine for Farm Woodlands in Northern Mississippi," presented figures showing that using the International ¼″ Rule the mill scale overran the log scale from 12 per cent on 10-inch logs to 100 per cent on 5-inch logs, with an unweighted average overrun of 40 per cent for 5-10 inch logs. At present prices and manufacturing standards shortleaf pine lands in

Alcorn County cut each 10-30 years should return an annual gross rental of from \$.75 for understocked, poorly managed land to \$2.50 per acre for well-stocked, well-managed lands. This represents from 3.2 to 6.2 per cent (gross taxes to be deducted) on the capital value of the land and forest. *The most important point in keeping timber growing costs down is to avoid high capital cost and consequent high carrying charges.* This is possible if the original forest is never wiped out, but kept reproducing naturally, and the growing stock only partly liquidated by periodic "selective" cuttings. In timber growing costs the farmers have a great advantage over the large forest properties in much smaller charges for administration, protection, and particularly taxes. In farming counties the proportion of the real property tax base in farm lands is relatively large, so that the second growth farm forest lands need produce a smaller part of the total tax income than must the second growth lands in the counties dominated by the large cut-over forest land holdings.

D. E. Lauderburn in his discussion said he felt the farm as a whole should be considered. He thought improved markets will result in a yield of over 6 per cent. Unearned increment will help. Better marketing by the farmer is essential. Lumber companies have not considered timber as anything permanent. Farmers are more concerned with woods than timber companies, and have an advantage over the large forest owner in lower assessed valuation and a diversity of interests to help in times of depression.

G. H. Lentz read a paper on "Soil Erosion in the Silt Loam Uplands of Mississippi," by Lentz, Sinclair, and Meginnis. The study is being conducted in the lower Mississippi Valley in a loess formation east of the river and south of the Ohio, an area roughly 500 miles long and 50 to 75 wide. From 8.3 to .8 per cent of the counties surveyed has been found to be eroded, with the worst erosion in the north. Factors recognized as important thus far are: Temperature difference, variations in depth of loess, changes in underlying strata, frequency of fires, past farming practices and their extent. Contrary to previous reports, erosion has been less active where the loess is deepest. Most of the erosion seems to have taken place since the Civil War, but no exact histories are obtainable. The problem is steadily growing worse. Little or nothing is being done to stop this destruction. Unless something is done another Bad Lands area will take the place of what were once fertile farm lands.

The report of the Forest Type Committee was presented and accepted as the temporary type classification of the Section.

Twenty-eight gathered for dinner, at which the principal address was given by C. H. Guise of Cornell University, who is now serving as assistant director of the Forest Education Inquiry being conducted by the Society of American Foresters. He traced briefly the history of forest education in America and showed that in thirty-two years the schools have increased from one to twenty-five, and in thirty years the graduates from one to approximately three hundred in number. In view of the rapid expansion of this educational system, and the fact that so many young men are now studying forestry, it is extremely important to study the progress made to date and the existing status of the educational structure,

with a view to ascertaining its capabilities in educating and training men in the profession of forestry.

The Inquiry has a number of important aspects, but only three of these were discussed. First is the questionnaire study which is being made with the coöperation of the former students of the forest schools. Over 5,000 questionnaires were mailed, and returns from 43 to 70 per cent evidence the interest that the former forest school men are taking in this study. A second phase concerns itself with a detailed study at each of the existing forest schools of policies, financial support, other resources, teaching staff, and curricula. Third, the Inquiry is advising with employers and potential users of forest school graduates as to the capacities of the various industries to absorb foresters and the qualities that they want in their employees.

Problems of graduate study, research, vocational and ranger school training are all being given attention. The Inquiry started July 1, 1929, and will be completed June 30, 1931. The results will be issued in appropriate publications.

The following officers were elected for the ensuing year:

Chairman—G. D. Marckworth.

Vice-Chairman—E. A. Ziegler.

Secretary—Robert Moore.

Saturday morning, March 15, the group toured Livingston Parish. Stops were made at plots laid out by M. E. Brashears in his studies of the yield of loblolly pine straw to be used as a mulch in strawberry culture. Plot One, 21 years of age, produced 880 cubic feet of straw on one acre in 1929 worth $7.40, and in 1930 1,056 cubic feet per acre worth $10.30. Plot Two, 10 years old, produced crops valued in 1929 at $9.10 per acre, and in 1930 at $10.50 per acre.

Other stops were at a tie mill and thinning plots of the Great Southern Lumber Company. Eight plots were examined, thinned at the ages of 25 and 26 years to a final stand of 100 trees per acre to produce two logs per tree. From 12 to 23 cords were removed and from 12 to 23 cords left.

ROBERT MOORE,
Secretary.

SOCIETY MEMBERS HAVE INFORMAL MEETING IN CONNECTION WITH SOUTHERN FORESTRY CONGRESS

Some twenty-five members of the Society from the East and South assembled at the call of W. L. Hall for an informal evening session in connection with the Southern Forestry Congress at Memphis on April 10, 1930. Mr. Hall presided at the meeting and offered a number of interesting topics for discussion. Among them were, first, the question of the actual money value of the leaf crop and, second, the problem of an accumulating fire hazard in southern pine resulting from complete protection.

The discussion left little doubt of the fact that the annual crop of needles or leaves generally has a substantial value and that such value should be considered in reporting the loss resulting from forest fires. The evidence offered in support of the value of leaf litter included statements of actual chemical analyses, observations on the value of leaf litter when used as a fertilizer on the farm, measurements of forest trees showing reduced rate of growth resulting from the removal of litter, and finally reports of the sale of

needle litter at figures ranging up to $9.00 an acre annually in the strawberry section of Louisiana. It should be mentioned also that the removal of leaf litter under certain circumstances is helpful to seedling establishment. Several speakers commented on the fire reports turned in by the states and urged that the loss in value of forest litter be generally included.

Discussion of the problem of an increasing hazard in southern pine resulting from complete protection brought out generally hopeful comments and very little argument in favor of any form of controlled burning. The points brought out were briefly the following: Every fire does a certain amount of damage. Any hardwoods present are practically sure to be injured. The damage done by any large fire varies considerably in different parts of the area covered but seldom fails to kill or injure many trees. Periodic burns tend to kill out the young growth and lengthen the period between cuttings. The hazard in southern pine forests is higher with a greater quantity of grass, weeds, and bushes, such as develop under more or less open conditions. Decay is rapid in the South and the actual quantity of inflammable grass, needles, etc., is probably not materially added to after four to six years of protection. As the stands close in there is a lessening in the amount of such inflammable growth. The several states have protected considerable areas over periods long enough to test the systems under more than average severity of conditions and the results to date were considered successful.

Following this very interesting discussion, the meeting cordially welcomed the writer in the rôle of Executive Secretary for the parent Society. The meeting proceeded to discuss ways and means of developing the Society to perform a greater service to the profession and the public and the part that a paid secretary could play in that development. The discussion was most helpful since there is a difficult task ahead in making the time and funds devoted to this new office most effective.

W. R. Hine,
Executive Secretary.

Changes in Membership

The following men have been elected to the grade of membership indicated, effective April 1, 1930:

ALLEGHENY SECTION

Junior Membership

Coover, Chester A.
Kline, Ludwig V.
Morey, Harold F.
Vogenberger, Ralph A.
Ziegler, Russel M.

CENTRAL ROCKY MOUNTAIN SECTION

Junior Membership

Edmondson, W. O.
Iverson, Ray C.

GULF STATES SECTION

Junior Membership

Dexter, A. K.
Johnson, Seaborn J.

INTERMOUNTAIN SECTION

Junior Membership

Scribner, Clayton W.

MINNESOTA SECTION

Junior Membership

Anderson, Waldemar R.
Chase, Warren W.
Deters, Merrill E.
Kaufert, Frank H.
Kirkham, Dayton P.
Lawson, Edward L.
Ritter, Lawrence B.
Roe, Eugene I.
Verrall, Arthur F.

NEW ENGLAND SECTION

Junior Membership

Branch, Willis C.
Flint, Theodore C.
Palmer, E. Huntley
Porter, John W.

NORTH PACIFIC SECTION

Junior Membership

Briegleb, Philip A.
Childs, Thomas W.
Harpham, Vernon V.
Harrar, Ellwood S.
Moravets, Floyd L.
Nilsson, Adolph
Wilson, Sinclair A.

SOUTHEASTERN SECTION

Junior Membership

Bauer, Eitel
Beale, C. Bernard
Budd, Archie W.
Grant, B. F.
Thurmond, Jack

WISCONSIN SECTION

Junior Membership

Christensen, Irving L.
McLaren, C. G.

NO SECTION

Junior Membership

Cuzner, Harold
De La Cruz, Eugenio S.
Sajor, Valentin
Zamuco, Gregorio

Senior Membership

Dacanay, Placido

SOCIETY OFFICERS

Officers and Members of Executive Council

President, Paul G. Redington, Biological Survey, Washington, D. C.
Vice-President, John D. Guthrie, Forest Service, Portland, Oregon.
Secretary-Treasurer, E. Morgan Pryse, Office of Indian Affairs, Washington, D. C.

Executive Council

The Executive Council consists of the above officers and the following members:

	Term expires		Term expires
R. Y. Stuart	Dec. 31, 1931	Stuart B. Show	Dec. 31, 1933
Aldo Leopold	Dec. 31, 1931	W. G. Howard	Dec. 31, 1931
T. T. Munger	Dec. 31, 1931	Ralph S. Hosmer	Dec. 31, 1933
Clifton D. Howe	Dec. 31, 1933	Claude R. Tillotson	Dec. 31, 1933

Member in Charge of Admissions

W. G. Howard

Section Officers

Allegheny

G. H. Wirt, Chairman, Department of Forests and Waters, Harrisburg, Pa.
R. D. Forbes, Vice-Chairman, Allegheny Forest Exp. Sta., 3437 Woodland Ave., Philadelphia, Pa.
H. F. Round, Secretary, Forester's Office, Pa. R. R. Co., Philadelphia, Pa.

Appalachian

E. H. Frothingham, Chairman, Appalachian Forest Experiment Station, Asheville, N. C.
Verne Rhoades, Vice Chairman, P. O. Box 1927, Asheville, N. C.
W. K. Beichler, Secretary, N. C. Dept. Cons. & Devel., Asheville, N. C.

California

E. I. Kotok, Chairman, 340 Giannini Hall, Berkeley, Calif.
Woodbridge Metcalf, Vice-Chairman, 340 Giannini Hall, Berkeley, Calif.
M. R. Brundage, Secretary, 340 Giannini Hall, Berkeley, Calif.

Central Rocky Mountain

Allen S. Peck, Chairman, Forest Service, Denver, Colo.
John W. Spencer, Vice-Chairman, Forest Service, Denver, Colo.
J. A. Donery, Secretary, Forest Service, Denver, Colo.

Gulf States

G. D. Marckworth, Chairman, Louisiana State University, Baton Rouge, La.
E. A. Ziegler, Vice-Chairman, Southern Forest Experiment Sta., New Orleans, La.
Robert Moore, Secretary, University Station, Baton Rouge, La.

Intermountain

Lyle F. Watts, Chairman, Forest Service, Ogden, Utah.
Earl C. Sanford, Vice-Chairman, Forest Service, Ogden, Utah.
S. B. Locke, Secretary, Forest Service, Ogden, Utah.

Minnesota

C. G. Bates, Chairman, University Farm, St. Paul, Minn.
R. M. Brown, Secretary, University Farm, St. Paul, Minn.

New England

Austin F. Hawes, Chairman, State Forester, Hartford, Conn.
A. C. Cline, Secretary, Harvard Forest, Petersham, Mass.

New York

Arthur S. Hopkins, Chairman, Conservation Dept., Albany, N. Y.
H. C. Belyea, Secretary, College of Forestry, Syracuse, N. Y.

Northern Rocky Mountain

I. W. Cook, Chairman, U. S. Forest Service, Missoula, Mont.
S. N. Wyckoff, Vice-Chairman, U. S. Forest Service, Spokane, Wash.
I. V. Anderson, Secretary, U. S. Forest Service, Missoula, Mont.

North Pacific

Hugo Winkenwerder, Chairman, College of Forestry, University of Washington, Seattle, Wash.
Fred W. Cleator, Secretary-Treasurer, Box 4137, Portland, Ore.

Ohio Valley

E. F. McCarthy, Chairman, Central States Forest Exp. Sta., Ohio University, Columbus, Ohio.
F. W. Dean, Secretary, Morrison Hill, Wooster, Ohio.

Southeastern

Harry Lee Baker, Chairman, State Forester, Tallahassee, Fla.
B. F. Lufburrow, State Forester, Atlanta, Ga.
H. A. Smith, Secretary, Asst. State Forester, Tallahassee, Fla.

Southwestern

G. A. Pearson, Chairman, Forest Service, Flagstaff, Ariz.
D. A. Shoemaker, Vice-Chairman, U. S. Forest Service, Albuquerque, N. M.
H. Basil Wales, Secretary, U. S. Forest Service, Albuquerque, New Mexico.

Washington

Barrington Moore, Chairman, 1520 K St., N. W., Washington, D. C.
Alfred E. Fivaz, Secretary, Bureau Plant Industry, Washington, D. C.
R. E. Marsh, Member of Executive Committee, Forest Service, Washington, D. C.

Wisconsin

F. G. Wilson, Chairman, College of Agriculture, Madison, Wis.
Edward C. Peck, Secretary, 2001 Monroe St., Madison, Wis.